POVERTY AND ENVIRONMENTAL SUSTAINABILITY IN INDIA: AN ECONOMIC ANALYSIS

ABSTRACT

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ABSTRACT

POVERTY AND ENVIRONMENTAL SUSTAINABILITY IN INDIA: AN ECONOMIC ANALYSIS

India is a large country both in terms of population and poverty. Hence, for it, an environmentally sustainable development is not an option but a requirement. On one hand, India is faced with environmental degradation from poverty and population pressures, and on the other, from pollution from careless and increased human activities due to economic growth and the consequent changing consumption patterns. While the poor disproportionately depend on the environment for their income and livelihood, the process of economic development relies on using natural resources to produce goods and services. The waste generated from consuming and producing these goods and services are, in turn, released back into the environment that affects it adversely. The environment provides security for present and future generations. The health of the environment is closely related to the health of humans, and it has been found economically beneficial for countries to prevent environmental degradation. Since the environment in most of the developing countries is not an amenity but a necessary input for the rural households, environmental degradation in turn implies a shrinking input base for the poor households that increase the severity of poverty. The challenge, therefore, in making development compatible with the environment is to restructure the economic system in a way that it will not destroy the environment as economic progress continues.

Empirical validation of the rural poverty-environment nexus has profound policy implications especially for a developing country like India where more than 60 percent workforce is employed in agriculture and allied sectors which are mainly natural resource based. Most of them are low income poor people. India houses 301.7 million poor out of which 220.9 million (73.2 percent) live in rural areas. Hence, degradation in environment will have an adverse impact on the lives of the poor in rural areas and the efforts to alleviate poverty may be bogged down.

Taking into consideration the objectives and hypotheses formed in the study, the present work has been planned in the following sequence:-

The whole thesis is divided into eight chapters. The first chapter is 'introductory' which states the relevance and need of the study in Indian context, and outlines the objectives, hypotheses to be tested, database used, and methodology adopted in the study. Second chapter makes an in-depth study of review of literature. Third chapter analyses the economic growth, inequality and poverty in India in the pre and post reform period. Fourth chapter discusses the relationships between population, poverty and education. India's environmental status has been reviewed in chapter five. Sixth chapter is the core of the thesis under which the interrelationships between population, poverty and environment in India have been explored. The last chapter i.e., chapter seven summarises the findings with concluding observations and suggestions have been made for taking policy measures.

Chapter-wise summary of the study is as follows:

Chapter-I: Introduction

The chapter is 'Introductory' which states the relevance and need of the study in Indian context, and outlines the objectives, hypotheses to be tested, database used, and methodology adopted in the study.

Significance of the Study

Empirical validation of the rural poverty-environment nexus has profound policy implications especially for a developing country like India where more than 60 percent workforce is employed in agriculture and allied sectors. Most of them are low income poor people. India houses 301.7 million poor out of which 220.9 million (73.2 percent) live in rural areas. Therefore, a careless and unsustainable use of natural resources will have adverse impact on them. Hence, it is important for policies geared to improve environmental quality to take into consideration the effect of poverty on environmental quality. Similarly, policies aimed towards reducing poverty should also take into account the impact of environmental quality on poverty. Sometimes, a thoughtless pro-poor policy may actually prove to be

anti-poor when the resource base of income and employment of the poor are subjected to degradation. Existence of a poverty-environment nexus, therefore, implies that the policies often fail to treat these two issues in a unified framework.

Objectives of the Study

The main objective of the study is to establish, if any, the causal relationships between population, poverty and environmental degradation in India. Since, literatures on poverty and environmental degradation relationships talk about bi-directional relation between them, our objective is to test whether such relationships exist in Indian situation.

Specific Objectives

The specific objectives of the study are as follows:

1. To examine the structural changes in the net national product (NNP), per capita net national product (PCNNP), and population in India between pre and post-reform period
2. To analyse the trends in income disparities between Indian states in pre and post-reform period
3. To examine the poverty trends in India in pre and post-reform period
4. To look into trends and disparities in population growth and its determinants in India
5. To examine the relationships between population, poverty and environment in India

Hypotheses

The major objective of the present study is to examine the relationships between population, poverty and environment in India. To achieve the said objective, the study has formulated the following four hypotheses:

(1) Poverty leads to population growth

(2) Population Growth causes environmental degradation

(3) Rural poverty increases environmental degradation

(4) Environmental degradation spurs rural poverty

Database and Methodology

The study is entirely based on secondary sources of data collected from different official documents and websites of Government of India. Techniques of statistics and econometrics have been applied for analysing the data and getting the results to derive logical conclusion. Besides simple statistics like means, coefficient of variations, correlation coefficients, rank correlation coefficients, the study also uses t-statistics to test statistical significance, dummy variable technique to test structural change in a function, σ-convergence test and β-convergence test to see the trends in income disparity among the Indian states between pre and post reform period, and simple regression, stepwise regression analysis to establish functional relationships among the variables. The study also calculates annual compound growth rate and arc elasticity of poverty with respect to per capita net state domestic product and net state domestic product for comparative analysis of variables between the two periods. Poverty index, environment index and poverty-environment composite index were constructed for spatial and temporal comparisons.

Chapter-II: Poverty-Environment Relationships: A Literature Review

Past studies pave the way for future research endeavour. An acquaintance with earlier pertinent studies has been felt necessary in order to identify the unexplored part of the earlier studies, to develop a better understanding of the problem under present study and to formulate an appropriate research methodology in the light of understanding of the tools adopted by the earlier studies. Hence, an attempt has been made in this chapter to review some of the previous studies on the relationships between poverty and environment. The chapter reviews the past studies undertaken in India as well as outside India to have an idea about the methodologies adopted, their findings and limitations.

The review of the previous studies reveals that there is a complex causal relationship between poverty and environment. There is a two-way causal relationships between poverty and environmental degradation, i.e., poverty causes

environmental degradation and vice verse. But these relationships are often found to be indirect. Moreover, it does not imply that the rich do not cause the environment to degrade. In fact, whether the environmental degradation is caused by the rich and powerful or by the poor depends on the nature of environmental degradation. While the rich as well as the poor could be the agent for environmental pollution, the adverse impact of it is disproportionately on the poor due to their dependency on natural resources for income, employment and livelihoods.

There are several limitations of the previous studies reviewed. Most of these studies focus on the effect of poverty on environment or infers about the other direction of the relationship on the basis of extent of dependence of poor on natural resources. The relationship between poverty and environment has been analyzed in literature mostly by descriptive and empirical studies.

Since, the poverty-environment 'nexus' hypothesis argues that there is a cyclical relationship between rural poverty and environmental degradation, it implies that poverty change and environmental change are jointly endogenous. Yet, in spite of the assertion of existence of such a nexus, the empirical studies have not accounted for this endogeneity. Failure to account for the endogeneity can provide biased results. The present study takes into consideration this endogeneity and tries to see whether such cycle exists in rural areas of India.

Chapter-III: Economic Growth, Income Disparities and Poverty in India: A Comparative Analysis of Pre and Post-reform Period

The Indian economy attained a higher growth trajectory in the post-reform period. As a result of which, poverty in India at national level in terms of head count ratio has substantially declined in the post-reform period as compared to that in the pre-reform period, indirectly through the working of trickle-down effect and directly through launching up of different programmes to alleviate poverty and generate employment facilitated by higher economic growth achieved in the post-reform period. However, the impressive growth achieved in the post-reform period alone does not ensure that all the Indian states, irrespective of their socio-economic status, have also been equally benefited on socio-economic fronts. It is quite

possible that in spite of higher growth, the pattern of growth could not have been conducive to alleviation of poverty equally across states. It is also likely that the rich states may have benefited largely from the economic reforms as they were better equipped with socio-economic infrastructures and the poor states because of poor infrastructural facilities lagged behind.

Our in-depth study using analytical tools of statistics and econometrics offers certain evidences on growth, inequality and poverty in India. The structural stability test using dummy variable technique shows that there have been significant upward shifts in the net national product and per capita net national product function in India in the post reform period as a consequence of major economic policy shifts in 1991 popularly known as the economic reform. Although net national product and per capita net state domestic product both experienced spectacular rise in real terms in the post-reform period, the impressive growth in per capita income cannot be solely attributed to the economic reform of 1991. The structural stability test applied on population function showed that it witnessed a significant downward shift in the post-reform period. Hence, the improvements in standard of living of people in India as reflected in real per capita income in the pos-reform period was also partially due to slow down in the population growth rate besides the higher economic growth in the post-reform period.

It is quite worrying that while there has been overall impressive achievement on growth fronts in India, the growth disparity between the agriculture and non-agriculture sectors has widened in the post-reform period. The poor in India is still mostly concentrated in rural areas and they are mainly dependent on agriculture and allied sectors. Each of agriculture & allied and agriculture sector witnessed a significant fall and the industrial sector a slight rise in annual compound growth rate in the post-reform period. Only service sector registered a marked rise in its annual compound growth rate in the post-reform period. Service sector was the only sector which witnessed a significant positive structural change in its growth rate in the post-reform period.

Both σ-convergence test and β-convergence test were applied on initial per capita net state domestic product to see the trends in income disparity among the

Indian states during pre and post reform period. The results showed that Indian states were diverging in the pre-reform period and they continue to diverge in the post-reform as well. However, the rate of divergence has slightly slowed down in the post-reform period. Similar results came through the use of dummy variable techniques used for testing the convergence between the rich and the poor states of India in terms of proportionate growth in real per capita net state domestic product.

The change in the sectoral pattern of growth in the post-reform period has been neither in favour of the poor states nor in favour of the poor people in India. The impressive increase in growth rate in non-agriculture sector particularly in service sector and considerable slow down in the agricultural sector growth rate in the post-reform period resulted in economic disparities between the rich and the poor states of India in the post-reform period. This could be due to the fact that most of the states which are heavily populated also house most of the poor people who are mainly dependent on agriculture for their income and employment. The increasing economic disparity partly explains that the benefits of higher economic growth in India in the post-reform period were largely appropriated by the rich states and the rich people.

The arc elasticity of poverty with respect to per capita net state domestic product in India was estimated to be 2.093 in the pre-reform period which declined to 1.826 in the post-reform period. Out of the major eight states of India which witnessed deterioration in their poverty elasticities (arc elasticity of poverty), four were the so called BIMARU states. Uttar Pradesh was the only BIMARU state which registered a slight improvement in its poverty elasticity in the post-reform period.

Thus, India has partially failed in translating the higher growth achieved in the post-reform period into poverty reduction effectively. Hence, in spite of impressive economic growth the achievement on poverty front has not been so impressive during the post-reform period.

Chapter-IV: Population Growth, Poverty and Education: Evidence from India

For a developing country like India growth in population proves to be a net burden due to lack of adequate resources to invest in health and education. India has achieved some success on population front but there is still a lot of scope for the reduction of population growth rate in many Indian states. There are particularly high rates of population growth in most of the North-eastern and BIMARU states of India. The population in large and poor Indian states namely Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh and Orissa (together termed as BIMARU states) continues to grow at a very high rate.

A model with explanatory variables as a combination of quantitative and qualitative variables and population growth rate as dependent variable (known as ANCOVA model) was estimated following step-wise regression method to identify factors contributing to population growth in India.

The preference for male child, poverty and illiteracy are found to be the major factors contributing to population growth in India. The prevalence of high infant and child mortality rates in relatively poor states are also contributing to high growth rate in population in these states. The low chance of the survival of a child leads poor people to have more children to avoid the risk of being child-less and, hence, income insecurity in old age. Thus, the study accepts the hypothesis that poverty leads to population growth in India.

Chapter-V: India's Environmental Status: A Review

The study did trends analysis using line graphs, bar charts, pie charts and calculating percentage change. The trends' analysis shows that India's environment as reflected in land, air, water and forests resources have been considerably degraded. Use of modern technology in farming sector has damaged its soil and water resources. Intensive use of land and water resources made possible by modern technology has resulted in over-exploitation of these resources. Increasing level of air pollution particularly in urban areas is posing health problems. The main sources for air and water pollution are growth in vehicles, urbanisation and

rapid industrialization. Due to poverty, low income and illiteracy in rural areas of India, people use traditional sources of energy for cooking and lighting. This is causing indoor air pollution in rural areas of India. The poor are main victims of environment related diseases (acute respiratory infections and TBs) due to such indoor air pollution as they are more exposed to them than the rich.

Chapter-VI: Population, Poverty and Environmental Sustainability: An Interrelationship

The study provides some insights into the interrelationships between population, poverty and environmental degradation and other socio-economic factors affecting them that might be useful for policy formulations for rural development and environmental planning.

The correlation coefficient between population growth and change in forest cover is found to be negative and statistically significant. Population growth has a negative impact on environment in many ways. The growing population leads to rise in demand for food, timber for housing and fuel, and transportation which causes deforestation and air pollution. It raises the demand for water for agricultural, industrial and domestic purposes which leads to waste water generation, river and underground water pollution. The growth in population leads to decline in per capita non-renewable natural resources leading to intensive and extensive use of them and hence their degradation. Population growth increases the rate of waste water generation and solid waste generation. Hence, the study accepts the hypothesis that population growth increases environmental degradation.

The rural India as a whole witnessed a significant progress in poverty reduction. However, the progress made was uneven across the states. Punjab, Haryana, Uttar Pradesh, Rajasthan, Bihar, Gujarat, Himachal Pradesh, Orissa and Madhya Pradesh were the states which witnessed lowest decline in rural poverty during 1977-78 to 2004-05. These include all the five BIMARU states which still have the largest poverty ratio in rural areas.

Poverty, environment, and poverty-environment composite indices were constructed in order to analyse rural poverty and environmental degradation in

India between 1987-88 and 2004-05. The analysis of Poverty, environment, and poverty-environment composite indices based on state-wise secondary data did not yield any definite pattern in poverty environment linkage in rural India. Forests cover in many states and at national level has increased due to reforestation programmes of the government. This could be one reason for the unexpected results. However, the regression analysis of cross sectional data of smaller units (block level) on rainfall, and dispersion in temperature using dummy variables for BIMARU and North-eastern states shows that the environment in BIMARU states and North-eastern states of India has deteriorated between 1991 and 2001. Hence, poverty seems to have caused the degradation of environment in these states. We used dummies for the above two groups of states, since rural poverty ratios were high in them during 1991-2001 and the BIMARU states have very low percentages of land area under forests cover. Since the study also find that poverty causes population growth and population growth causes environmental degradation in multiple ways we infer from this that poverty leads to increase in environmental degradation through rise in population in long run. Thus the study accepts the hypothesis that rural poverty increases environmental degradation.

The correlation coefficients between rural poverty ratio and solid fuel use in rural areas and that between solid fuel use and environmental pollution related diseases in rural areas are found to be positive and statistically significant. Hence, poverty-environment vicious cycle seems to be in operation in rural areas in that poverty leads to increase in solid fuel use which in turn causes deforestation, air pollution and pollution related diseases among the rural poor.

The study infers from the above findings that forests and rainfall degradation, and environmental pollution increase the severity of rural poverty as the poor are largely dependent on agriculture and allied sectors which are mainly natural resource-based. The poor are also more exposed to air and water pollution due to their poor nutritious and housing conditions. Hence, environmental degradation spurs rural poverty and rural poverty causes environmental degradation which leads us to accept the third hypothesis i.e., environmental degradation spurs rural poverty in India.

The results also depict that social factors also play important role in environmental change and poverty change. Education helps in adopting clean-technology and valuing the environment. The BIMARU states of India are characterized by high poverty ratio, low literacy rates, poor demographic features (high population growth rate, high fertility rate, etc.), and poor health indicators (high infant mortality rate, low life expectancy, lack of sanitation and access to safe drinking water). In short, these states rank very low in human development indicators. Since the combined population of the five BIMARU states is more than 40 per cent of India's total population, the poor socio-economic conditions of these states naturally pull the overall socio-economic conditions of India down a great deal. The poor in these states are largely dependent on agriculture for their livelihoods. A vast area of land is degraded due to water erosion in these states. The quality of the environment, as reflected in the forest and rainfall degradation, has deteriorated in the BIMARU states. Moreover, these states (Bihar, Uttar Pradesh and Rajasthan) have a very low area of forests cover of their total land mass. Therefore, reforestation can play an important role in moderating the influence of floods, checking soil erosion, maintaining fertility of soil, conserving water, and regulating hydro-cycles in these states. Hence, a harmonized development of human, social and natural capital is required for the sustainable development of the BIMARU states. The same would also help in raising the level of sustainable development in India a great deal.

Chapter-VII: Findings, Conclusion and Suggestions

Finally, in the light of the in-depth analysis of relevant data the study comes with some important findings. Our in-depth study using analytical tools of statistics and econometrics offers certain evidences on growth, inequality and poverty in India. There have been significant upward shifts in the growth rates of net national product and per capita net national product in India as a consequence of major economic policy shift in 1991 popularly known as the economic reform. Out of the major eight states of India which witnessed deterioration in their poverty elasticities (arc elasticity of poverty), four were the so called BIMARU states. Uttar Pradesh

was the only BIMARU state which registered an improvement in its poverty elasticity in the post-reform period.

India has achieved some success on population front but there is still a lot of scope for the reduction of population growth rate in many Indian states. There are particularly high rates of population growth in most of the North-eastern and BIMARU states of India. Population in large and poor Indian states namely Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh and Orissa continues to grow at a very high rate. The preference for male child, poverty and illiteracy are the major factors contributing to higher population growth in India. The prevalence of high infant and child mortality rates in relatively poor states are also contributing to the high growth rate of population. The low chance of the survival of a child leads poor people to bear more children.

Poverty does not cause all types of environmental degradation. Poverty is, however, found to cause degradation in forests which play vital role for maintaining environmental quality. Poverty leads to environmental degradation by causing population growth and density in a multiple way. The study infers in consonance with the dominant view in the literature that poverty spurs environmental (forests and rainfall) degradation. The analysis of state and block level data on forests, rainfall and temperature shows that the environment in poor and backward BIMARU states and North-eastern states of India has deteriorated.

Conclusion

Forests and rainfall degradation adversely affect the agricultural productivity and income and employment of the poor in rural areas. Environmental pollution also increases the severity of rural poverty in that it decreases their working capacity and increases medical expenses. In fact the poor are found to be main victims of environmental degradation. Hence, environmental degradation increases rural poverty and rural poverty spurs environmental degradation. Poverty-environment vicious circle seems to be in operation in rural areas in that poverty leads to increase in solid fuel use which in turn causes diseases among the rural poor.

Poverty in India is largely concentrated in rural areas. Around 72 percent poor in India live in rural areas. The rural poor are largely dependent on agriculture and allied sectors which are mainly dependent on natural resources. A vast area of agricultural land (about 40 percent) is still dependent on rainfall. Hence, we should not deviate from the policy of making a joint attack on poverty and environmental degradation. Since poorest of the poor eke out their precarious living from natural resources like forests, rivers, lakes etc. environmental degradation would undoubtedly have its effects on them. Similarly increase in incidence of poverty would surely increase the desperate onslaught on Nature.

Therefore, careless and unsustainable uses of natural resources have adverse impact on the poor. Sometimes, a thoughtless pro-poor policy may actually prove to be anti-poor when the resource base of income and employment of the poor are subjected to degradation. At other, the poor have no option but to over-exploit natural resources for income and livelihoods. Existence of a poverty-environment nexus, therefore, implies that the policies often fail to treat these two issues in a unified framework. Hence, it is important for policies geared to improve environmental quality to take into consideration the effect of poverty on environmental quality. Similarly, policies aimed towards reducing poverty should also take into account the impact of environmental quality on poverty.

Suggestions

Finally, in the light of the problems currently being faced by India, we offer some suggestions which can prove to be effective for its environmentally sustainable development. Solid waste and waste water generation from houses should be subjected to tax based on households size, tax on industries based on pollution load, appropriate pricing of the natural resources, reducing subsidies on fertilizers and pesticides, promoting clean technologies, efficient irrigation, vermiculture and organic manures, people's participation, environmental education and awareness and effective use of right to information are some important ways through which the environmentally sustainable development in India can be achieved.

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Certificate

This is to certify that ***Mr. Md. Fakhre Alam*** has worked for his Ph.D. degree under my supervision on ***"Poverty and Environmental Sustainability in India: An Economic Analysis"***. This thesis is his original work and is suitable for submission for the award of Ph.D. degree in Economics.

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29/12/09

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(Supervisor)

DECLARATION

I, **Md. Fakhre Alam**, hereby declare that the thesis entitled "**POVERTY AND ENVIRONMENTAL SUSTAINABILITY IN INDIA: AN ECONOMIC ANALYSIS**", submitted to the Aligarh Muslim University, Aligarh in partial fulfillment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY IN ECONOMICS** is a record of original and independent work done by me under the supervision and guidance of **Dr. Md. Abdus Salam**, Reader in Economics, Aligarh Muslim University, Aligarh, and it has not formed the basis for the award of any Degree/Associateship/Fellowship or other similar title to any candidate in any university.

Md. Fakhre Alam

(MD. FAKHRE ALAM)

Signature of the Candidate

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MD. FAKHRE ALAM

GLOSSARY

ACGR	Annual Compound Growth Rate
C.S.O	Central Statistical Organisation
C.V	Co-efficient of Variation
CBR	Combined Birth Rate
CDR	Combined Death Rate
CNGR	Combined Natural Growth Rate
CO	Carbon Monoxide
CO_2	Carbon-dioxide
CPRs	Common Property Resources
D.I	Differential Intercept
D.S.C	Differential Slope Co-efficient
DT	Dispersion in Temperature
EKC	Environmental Kuznet's Curve
$E_{PR, PCNSDP}$	Elasticity of poverty ratio with respect to per capita net state domestic product
$E_{PR,NSDP}$	Elasticity of poverty ratio with respect to net state domestic product
EQ	Environmental Quality
G.A	Geographical Area
IDA	International Development Agency
IMD	Indian Meteorological Department
IPCNSDP	Initial Per Capita Net State Domestic Product
NFHS	National Family Health Survey
NNP	Net National Product
NO_2	Nitrogen Dioxide
NSDP	Net National Product
NSS	National Sample Survey
PCNSDP	Per Capita Net State Domestic Product
PG	Proportionate Growth
PR	Poverty Ratio
RBR	Rural Birth Rate
RDR	Rural Death Rate
RNGR	Rural Natural Growth Rate
S.D.	Standard Deviation
SDP	State Domestic Product
SO_2	Sulphur Dioxide
SPM	Suspended Particulate Matter
UBR	Urban Birth Rate
UDR	Urban Death Rate
UNGR	Urban Natural Growth Rate
URP	Uniform Recall Period
VIF	Variance Inflation Factor

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CHAPTER-I
INTRODUCTION

India is a large country both in terms of population and poverty. Hence, for it, an environmentally sustainable development is not an option but a requirement. On one hand, India is faced with environmental degradation from poverty and population pressures, and on the other, from pollution from careless and increased activities due to economic growth and the consequent changing consumption patterns. While the poor disproportionately depend on the environment for their income and livelihood, the process of economic development relies on using natural resources to produce goods and services. The waste generated from consuming and producing these goods and services are, in turn, released back into the environment that affects it adversely. The environment provides security for present and future generations. The health of the environment is closely related to the health of humans, and it has been found economically beneficial for countries to prevent environmental degradation. The challenge, therefore, in making development compatible with the environment is to restructure the economic system in a way that it will not destroy the environment as economic progress continues.

The poverty-environment link in the developing countries has been gaining increasing attention of the international development agencies and policy makers (Angelsen, 1997). This study is an attempt to advance the understanding of this link by focusing on specific aspects of environment, namely, forest, rainfall, and temperature and investigates its bi-directional relationship with poverty.

Many studies have established that the rural poor in developing countries are heavily dependent on local natural resources for their sustenance (Cavendish, 2000; Jodha, 2000; Shiva & Verma, 2002; Escobal and Aldana, 2003; Narain, Gupta & Veld, 2005). Due to weak property rights and limited access to credit, insurance and capital markets, rural poverty leads to resource degradation in many ways (Dasgupta and Mäler, 1994; Mäler, 1997; Swinton, Escobar and Reardon, 2003; Bahamondes, 2003). The poor are heavily dependent on the open-access resources (Common Property Resources or CPRs) like the forests, pastures, and water resources that lead to their over exploitation (Jodha, 2000). Animals like sheeps or goats that act as capital resources for the rural poor degrade the vegetation and soil faster than the livestock of the richer rural population like buffaloes (Rao, 1994). The poor degrade cultivable land quickly due to lack of investment for maintaining the soil quality that erodes the soil fertility (Reardon and Vosti, 1995). Land tenure system also plays a crucial role in the investment for maintaining soil quality. Since the environment in most of the developing countries is not an amenity but a necessary input for the rural households, environmental degradation in turn implies a shrinking input base for the poor households that increase the severity of poverty (Mink, 1993; Jodha, 2000). This cyclical relationship is generally referred to as the poverty-environment nexus (Nelson and Chomitz, 2004; Dasgupta, et al., 2003; Duraiappah, 1998).

It has been observed that economic growth is a necessary but not sufficient condition for rapid decline in poverty in a country. Although higher economic growth alone does not ensure substantial decline in poverty, it is still considered a

powerful instrument in the hands of the government for the removal of poverty. The higher economic growth provides the government the opportunity to not only promote developmental activities in a more comprehensive way but also undertake direct measures for poverty alleviation and employment generation programmes at large scale. Exactly this has happened in India in the post-reform period. The Indian economy attained a higher growth trajectory in the post-reform period. As a result of which, poverty in India at national level in terms of head count ratio has substantially declined in the post-reform period as compared to that in the pre-reform period, indirectly through the working of trickle-down effect and directly through launching up of different programmes to alleviate poverty and generate employment facilitated by higher economic growth achieved in the post-reform period. However, the impressive growth achieved in the post-reform period alone does not ensure that all the Indian states, irrespective of their socio-economic status, have also been equally benefited on socio-economic fronts. It is quite possible that in spite of higher growth, the pattern of growth could not have been conducive to alleviation of poverty equally across states. It is also likely that the rich states may have been benefited largely from the economic reforms as they were better equipped with socio-economic infrastructures and the poor states because of poor infrastructural facilities lagged behind.

Different researchers have differing views regarding the impact of economic reforms on growth, inequality, poverty and unemployment in India. In spite of higher overall growth the extent of decline in poverty in the post reform period had not been higher than in the pre-reform period. Inequality increased significantly in

the post-reform period which slowed down the rate of poverty reduction (Dev and Ravi, 2007). In the post-reform period, rural poverty reduction had been arrested but urban poverty recorded a significant decline during the 1990s, the inequalities in consumption distribution was higher in the post-reform period as compared to pre-reform period, and the quality of employment declined (Dev, 2000). Per capita income did not show any significant trend in regional disparity over the period 1981-2001. Seven out of nine human development indicators displayed a declining trend and 12 of the 16 related social and human development indicators showed a marked decline in regional disparity during 1981-91 (Dholakya, 2003). Poverty decline in the 1990s proceeded more or less in line with earlier trends (Deaton and Dreze, 2002). Regional disparities increased in the 1990s, with the Southern and Western regions doing much better than the Northern and Eastern regions. Economic inequality also increased in and within states and, especially within urban areas and between urban and rural areas (Deaton and Dreze, 2002). In the light of data from the National Sample Surveys, poverty in India was less than 15 percent in 1999-00 which was nearly half the official government of India estimate of 26 percent (Bhalla, 2003). The key determinants of the rate of poverty reduction at state level are agricultural yields, growth of the non-farm sector (depending on the state's initial conditions) development spending, and inflation. The rate of poverty reduction in the 1990s was slightly lower than the 1980s, and lower than one would have expected given the growth in the 1990s (Datt, Kozel and Ravallion, 2003). There is wide variation in poverty incidence within states, particularly, but not exclusively, the larger states ones. Furthermore, regional inequality in the

incidence of poverty has persisted over time and the economic reforms programmes were unable to make any significant dent on the spatial distribution of incidence of poverty (Jha and Sharma, 2003). There has been considerable diversity in performance across states. By and large, the (farm and non-farm) growth in India during the 1990s had not been occurring in the states where it would have had the most impact on poverty nationally. There were also large differences across states in the poverty impact of any given rate of growth in non-agricultural output. States with relatively low levels of initial rural development were not well suited to economic growth (Datt and Ravallion, 2002).

Poverty fell far more rapidly in the 1990s than previously (Bhalla, 2000). Sen (2001) argued that poverty reduction in India stalled in the 1990s and it might have even risen. Using the Planning Commission's (2001) official poverty lines, Deaton (2000a) found that the rural poverty rate fell from 37.2 percent in 1993-94 to 30.2 percent in 1999-00, while the urban poverty fell from 32.6 percent to 24.7 percent. The annual rates of poverty reduction were 0.50 points per year for rural areas and 0.27 points per year for urban areas (Sundaram, 2001).

Empirical validation of the rural poverty-environment nexus has profound policy implications especially for a developing country like India where more than 60 percent workforce is employed in agriculture and allied sectors. Most of them are low income poor people. India houses 301.7 million poor out of which 220.9 million (73.2 percent) live in rural areas (www.planningcommission.nic.in). Therefore, a careless and unsustainable use of natural resources will have adverse impact on them. Hence, it is important for policies geared to improve

environmental quality to take into consideration the effect of poverty on environmental quality. Similarly, policies aimed towards reducing poverty should also take into account the impact of environmental quality on poverty. Sometimes, a thoughtless pro-poor policy may actually prove to be anti-poor when the resource base of income and employment of the poor are subjected to degradation. Existence of a poverty-environment nexus, therefore, implies that the policies often fail to treat these two issues in a unified framework. Since, the poverty-environment 'nexus' hypothesis argues that there is a cyclical relationship between rural poverty and environmental degradation, it implies that poverty change and environmental change are jointly endogenous. Yet, in spite of the assertion of existence of such a nexus, the empirical studies have not accounted for this endogeneity. Failure to account for the endogeneity can provide biased results. We have taken into consideration this endogeneity in our study.

Hence, the present study is an earnest attempt to explore the relationships between population, poverty and environmental degradation. It also explores priority areas and suggests policy measures to the Indian government for taking necessary steps to make the process of economic development in India sustainable.

1.1. Significance of the Study

Empirical validation of the rural poverty-environment nexus has profound policy implications especially for a developing country like India where more than 60 percent workforce is employed in agriculture and allied sectors. Most of them are low income poor people. India houses 301.7 million poor out of which 220.9 million (73.2 percent) live in rural areas. Therefore, a careless and unsustainable

use of natural resources will have adverse impact on them. Hence, it is important for policies geared to improve environmental quality to take into consideration the effect of poverty on environmental quality. Similarly, policies aimed towards reducing poverty should also take into account the impact of environmental quality on poverty. Sometimes, a thoughtless pro-poor policy may actually prove to be anti-poor when the resource base of income and employment of the poor are subjected to degradation. Existence of a poverty-environment nexus, therefore, implies that the policies often fail to treat these two issues in a unified framework.

1.2. Objectives of the Study

The main objective of the study is to establish, if any, the causal relationships between population, poverty and environmental degradation in India. Since, literatures on poverty and environmental degradation relationships talk about bi-directional relation between them, our objectives are to test whether such relationships exist in Indian situation.

Specific Objectives

The specific objectives of the study are as follows:

1. To examine the structural changes in the net national product (NNP), per capita net national product (PCNNP), and population in India between pre and post-reform period
2. To analyse the economic disparity between Indian states in the pre and post reform period
3. To examine the poverty trends in India in pre and post reform period

4. To look into trends and disparities in population growth across states and their relationships with poverty, education
5. To examine the relationships between population, poverty and environment in India

1.3. Hypotheses

Poverty is the worst economic disease. A developing country like India is characterized by widespread absolute poverty. The poor in a developing country are not able to fulfill even their basic needs. The poor may not afford to send their children to school for education as it involves trade-off. Because of very limited means, they care more for their sustenance and send their children to join labour market at the cost of their education. Hence, poverty and illiteracy often co-exist and are considered to be main hurdles in adopting modern means of contraception and small family norms. Therefore, we want to test the first hypothesis of the study as follows:

Hypothesis 1: Poverty leads to population growth.

Population growth puts pressure on environment. Increase in population is expected to increase environmental degradation which leads us to the second hypothesis of the present study.

Hypothesis 2: Population growth causes environmental degradation.

Despite the dominant view in the literature that poverty causes environmental degradation, there is some contradicting empirical evidence. Some studies show that traditional communities have managed the resources efficiently despite their poverty while others show that it is not the poor but the non-poor population

that deplete the rural environment. Hence the effect of poverty on the environment is an empirically testable issue. Based on the stated objectives of the study, the following hypotheses can be made for testing which may lead to either confirmation or rejection of the same. We want to test the dominant hypothesis that rural poverty spurs environmental degradation in India.

Hypothesis 3: Rural poverty increases environmental degradation.

Environmental degradation is a measure of change in environmental quality. Hence we test this hypothesis by estimating the effect of rural poverty on forests, rainfall and temperature- which are indicators of change in environment. We use only rural poverty ratio to assess the impact of poverty on the abovementioned indicators of environmental change since forests are found mainly in rural areas and both change in rainfall and temperature are largely determined by change in forests.

The literature acknowledges that dependence of the poor on environmental resources makes them vulnerable to environmental degradation. In the absence of (or limited) alternative employment opportunities, access to credit and capital markets and government policy interventions, environmental degradation is expected to increase the severity of poverty. This observation leads us to set up the fourth and the last hypothesis of the study as follows:

Hypothesis 4: Environmental degradation spurs rural poverty

This hypothesis is tested by estimating the effect of pollution related diseases on rural poverty. We use cross sectional data to test these hypotheses. Evidence in support of the last two hypotheses would be a confirmation of the existence of a cycle of poverty and environmental degradation in rural India.

1.4. Database

The study is entirely based on secondary sources of data collected from different official sources of Government of India. The sources of data used here are various agencies of the government of India which conduct annual, triennial and quinquennial surveys and decadal census. The data on different economic variables in India have been compiled from various publications and official websites of Government of India. The data on NNP at factor costs, per capita income has been collected from the Central Statistical Organisation (CSO). The annual estimates of population (interpolated annually for years between census of 1971, 1981, 1991, and 2001 and projected for years up to 2007 has been made based on the population data secured from Census Report of CSO and Directorate of Economics and Statistics. Meteorological subdivision-wise data on rainfalls and state-wise forest cover have been obtained from various issues of CMIE.

The data on population across states have been adopted from the Economic Survey, an official document published and issued by the government of India every year. The sources for annual data on birth rate, death rate, natural growth rate and total fertility rate are the Office of the Registrar General of India, which collects them on the basis of sample registration system. Data on total fertility rate for the three years preceding the survey, percentage of women age 15-49 currently pregnant, and mean number of children ever born to women age 40-49 by background characteristics in the year 2005-06 have been adopted from the National Family Health Survey-3, 2005-06. Data on total unwanted fertility rate and indicators of sex preference by state for women and men age 15-49 in year

2005-06 have also been adopted from National Family Health Survey-3, 2005-06. The district-wise data on sex ratio, overall literacy rate, percentage of urban population in 1991, and decadal population growth during 1991-01, were compiled from the Census of India, conducted in 1991 and 2001 respectively. The sources for data on educational level across Indian states in 2005 are NSS Report No. 515, 2004-05 available on the website www.mospi.gov.in.

Finally, the data on net national product, per capita net national product, net state domestic product, per capita net state domestic product, poverty ratio, district-wise data on decadal population growth rate, sex ratio, urban population, literacy rate, infant mortality rate have been taken from the official website www.planningcommission.nic.in of the Planning Commission, Government of India, which provides data in consolidated form. The block-wise data on average rainfall, maximum temperature and minimum temperature have been compiled from the Census Report, 1991 and 2001. Data on air pollution have been taken from Environmental Status Report, 2007. The source for data on solid fuel use is NSS Report No. 511: Energy Sources of Indian Households for Cooking and Lighting, 2004-05. Source for TB and acute respiratory cases is NFHS-3, 2005-06.

1.5. Methodology

The importance of a study to a great extent depends on the methods followed in the selection area, collection of data and the methods adopted for their analysis. While deciding the validity of the results of a study a clear understanding of the sources of data and the method followed in the study is found necessary. The methods of analysis adopted in the study have been explained below:

Scientific methods of statistics and econometrics were applied for analysing the data and getting the results to derive logical conclusion. Besides simple statistics like means, Coefficient of variations, correlation coefficients, rank correlation coefficients, .The study also used t-statistics to test statistical significance, dummy variable technique to test structural change in a function, σ-convergence test and β-convergence test to see the trends in income disparity among the Indian states between pre and post reform period, and simple regression, stepwise regression analysis to establish functional relationships among the variables. We also calculated annual compound growth rate and arc elasticity of poverty with respect to per capita net state domestic product and net state domestic product for comparative analysis of variables between the two periods. Poverty index, environment index and poverty-environment composite index were constructed for the spatial and temporal comparision.

We have calculated the Pearsonian Correlation coefficients in order to know the nature of relationships between total unwanted fertility rate and indicators of sex preference by state for women and men age 15-49 and also the relationships of total fertility rate with overall level of education, female educational level, poverty, and infant mortality rate. Since correlation alone does not establish a cause-effect relationship between the variables in question, theoretical underpinning and/or economic reasoning was supplied to establish a causal relationship.

(1) Average Annual Exponential Growth Rate

We used the following formula to calculate the average annual exponential growth rate of population during a given period of time:-

$$G = (1/n) \text{ Ln } (Y_1/Y_0)$$

Where, G = average annual exponential growth rate (%)

Y_1 = value in the final year of the period

Y_0 = value in the initial year of the period

n = no. of years contained in the period, and

Ln = exponential logarithmic operator.

(2) Annual Compound Growth Rate (ACGR)

The percentage annual compound growth rate in a variable has been calculated by first regressing the natural logarithm of the variable on time as follows:-

$$\text{Ln } Y_t = \beta_1 + \beta_2 t + u_t$$

Where, Y_t is the value of the variable in t^{th} year whose annual compound growth rate is to be found out, and t is the year. Numbers 1, 2, 3 etc. were used for the consecutive year.

And then we used the following formulae for getting compound growth rate (r):

$$r = [\text{anti Ln } (\beta 2)-1] \times 100$$

Where, r = annul compound growth rate (%)

(3) Structural Stability Test

For testing structural stability in a function (NNP, PCNNP or population function of time) between pre and post-reform period, the study used the dummy variable technique to minimize loss of degree of free. The model used is specified below:

$$Y_t = \alpha_0 + \alpha_1 t + \beta_0 D + \beta_1 (D t) + u_t$$

Where Y_t is the value of the variable in t^{th} year whose stability is to be tested; D is a dummy variable, t = 1, 2, 3 ... is used for consecutive year of the period.

D = 1, if an year belongs to post-reform period

= 0, otherwise (for pre-reform period).

α_0, α_1, β_0 and β_1 are parameters.

β_0 and β_1 are called differential intercept and differential slope coefficient respectively. The function experiences an upward positive shift in post-reform period if estimated value of β_0 or β_1 is positive or both are positive.

(4) σ and β-convergence Test

The first measure is the so-called σ-convergence. We measure the standard deviation across states of the logarithm of Per Capita Net State Domestic Product at factor cost (PCNSDP at factor cost) at constant prices. There is σ-convergence if the standard deviation across states tends to decline over time. The second measure is β-convergence. Under this measure, we regress the proportionate growth in Per Capita Net State Domestic Product at factor cost (PCNSDP at factor cost) at constant prices on the logarithm of Initial Per Capita Net State Domestic Product at factor cost (IPCNSDP at factor cost) at constant prices. There is β-convergence if the co-efficient of initial income, denoted by β, is negative and statistically significant.

In addition to the methods of σ and β convergences described above, we have also formulated the following model for testing the presence or absence of convergence among the Indian states:

$$PG_i = \alpha_0 + \alpha_1 D_i + u_i$$

D = 1, for the states whose rank on the basis of initial per capita state domestic product is 8 or less than 8 (termed as rich states)

= 0, otherwise, that is, for the states whose rank is greater than 8 (termed as poor states).

There is convergence between the rich and the poor states in a period if the co-efficient, α_1, of the estimated model is found to be negative and divergence if it is positive in that period.

Note: - In both pre and post-reform periods, the state with lowest initial per capita state domestic product is assigned rank 17 and the state with highest initial per capita state domestic product is assigned rank 1.

(5) Poverty Elasticity

In order to know the impact of economic growth on poverty in India in pre and post reform period, we have estimated the poverty elasticities in the two periods. We estimated the log-linear model as follows:

$$\text{Ln}\,(PR_{it}) = a_0 + b_0\,\text{Ln}\,(PCNSDP_{it})$$

Where, PR_{it} = poverty ratio of i^{th} state in t^{th} year; and $PCNSDP_{it}$ = per capita net state domestic product of i^{th} state in t^{th} year.

The above regression model was estimated using data on poverty atio (PR) and the corresponding real per capita net state domestic product (PCNSDP) of 17 major Indian states pooled from the years 1982-83 and 1993-94 for the pre-reform period and from the years 1993-94 and 2004-05 for the post-reform period. Our objectives are to estimate the poverty elasticities of per capita income. Therefore, we regressed the log of poverty ratio on log of per capita net national product. In such model, the coefficient of log of per capita net national product directly gives the poverty elasticity with respect to per capita net national product.

(6) We also calculated arc elasticities of poverty ratio in each of the 17 states with respect to per capita net state domestic product (PCNSDP) at factor cost and net state domestic product (NSDP) at factor cost in pre and post-reform period by using the following formula:

$$E_{PR,\ PCNSDP} = \frac{\%\text{ change in poverty ratio}}{\%\text{ change in PCNSDP}}$$

$$E_{PR,\ PCNSDP} = \frac{\%\text{ change in poverty ratio}}{\%\text{ change in NSDP}}$$

(7) To know the relative contribution of decline in birth and death rate in the natural growth rate in rural, urban and combined sector during 1881 to 2005, we estimated the log-linear model for rural, urban and combined sectors as follows:-

$$\text{Ln CNGR} = a_1 + b_1 \text{LnCBR} + c_1 \text{LnCDR}$$

$$\text{Ln RNGR} = a_2 + b_2 \text{LnRBR} + c_2 \text{LnRDR}$$

$$\text{Ln UNGR} = a_3 + b_3 \text{LnUBR} + c_3 \text{LnUDR}$$

Where CNGR = combined natural growth rate

RNGR = rural natural growth rate

UNGR = urban natural growth rate

CBR = combined birth rate

RBR = rural birth rate

UBR = urban birth rate

CDR = combined death rate

RDR = rural death rate

UDR = urban death rate

Ln = exponential logarithmic operator, and

$a_1, b_1, c_1, a_2, b_2, c_2, a_3, b_3, c_3$ are parameters.

(8) In order to identify the various factors determining the population growth in India, we developed a multiple linear regression model with a mixture of quantitative and qualitative regressors based on district-wise data by using stepwise regression. This type of model is known as the analysis of covariance (ANCOVA) model. Besides the three quantitative variables (sex ratio, overall literacy rate and percentage of urban population) known as covariates in the context of ANCOVA model, we also used seven qualitative (dummy) variables, one for each of Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, Orissa, BIMARU states, and North-eastern states. The model is specified below:-

$DPGR_i = a_0 + a_1 SR_i + a_2 OLR_i + a_3 UP_i + a_4 D1_i + a_5 D2_i + a_6 D3_i + a_7 D4_i + a_8 D5_i + a9 D6_i + a10 D7_i + u_i$

Where $DPGR_i$ = decadal population growth rate in i^{th} district during 1991-2001

SR_i = sex ratio in i^{th} district in 1991

OLR_i = overall literacy rate (%) in i^{th} district in 1991

UP_i = urban population (%) in i^{th} district in 1991

$D1_i$ = 1, if a district belongs to Bihar

= 0, otherwise

$D2_i$ = 1, if a districts belongs to Uttar Pradesh

= 0, otherwise

$D3_i$ = 1, if a district belongs to Madhya Pradesh

= 0, otherwise

$D4_i$ = 1, if a district belongs to Rajasthan

= 0, otherwise

$D5_i$ = 1, if a district belongs to Orissa

= 0, otherwise

$D6_i$ = 1, if a district belongs to BIMARU states

= 0, otherwise

D7i = 1, if a district belongs to North-eastern states

= 0, otherwise, and

a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9 and a_{10} are parameters.

The above model was estimated by using stepwise regression.

(9) Poverty and Environmental Degradation Indices

To make a meaningful spatial and temporal comparison of different states of India in terms of indicators of poverty, and forest cover, the following formulae are used to arrive at the degradation index of the indicator variables as mentioned below.

$PINDEX_{it} = 1 - [Max(X_{it}) - X_{it}]/[Max(X_{it}) - Min(X_{it})]$

Where $PINDEX_{it}$ is poverty index of the i^{th} state in t^{th} year; X_{it} is the rural poverty (%) of the i^{th} state in t^{th} year; Max (Xit) is the rural poverty (%) of the state with maximum rural poverty (%) in t^{th} year; and Min(Xit) is the rural poverty (%) of the state with minimum rural poverty (%) in t^{th} year.

$EINDEX_{it} = [Max(X_{it}) - X_{it}]/[Max(X_{it}) - Min(X_{it})]$

Where $EINDEX_{it}$ is environment index of the i^{th} state in t^{th} year; X_{it} is the rural poverty (%) of the i^{th} state in t^{th} year; Max (Xit) is the forest cover (%) of the state

with maximum forest cover (%) in t^{th} year; and Min(Xit) is the forest cover (%) of the state with minimum forest cover (%) in t^{th} year.

Lastly, an average composite index $PEINDEX_{it} = [PINDEX_{it} + EINDEX_{it}]/2$ was constructed using both poverty and environment indices for the purpose of comarision across states and over time where $PEINDEX_{it}$ is the poverty-environment index of the i^{th} state in t^{th} year.

The poverty index (PINDEX) has been formed by using rural poverty ratio of Indian states. The environment index (EINDEX) has been constructed on the basis of forest cover as a percentage of total geographical area in different states of India.

Poverty and environment indices were measured on 0-1 scale. The higher the value of poverty index, the higher the poverty level. The higher the value of environment index the lower the forest cover and thus higher the vulnerability of environment and environmental degradation on account of this indicator.

(10) Finally, we used block level data taken from Census of India, 1991 and 2001 on average rainfall and temperature to estimate the following model in order to see the trends in rainfall and dispersion in temperature in BIMARU and North-eastern states of India between 1991 and 2001. It is remarkable that rural poverty ratio were very high in the above two groups of states of India during 1991-2001.

$RF_{it} = a_0 + a_1\ BIMARU_{dummy} + a_2\ North\text{-}East_{dummy}$

$DT_{it} = b_o + b_1\ BIMARU_{dummy} + b_2\ North\text{-}East_{dummy}$

Where, RF_{it} = rainfall of i^{th} block in t^{th} year; DT_{it} denotes dispersion in temperature of i^{th} block in t^{th} year which is defined as maximum temperature minus minimum

temperature of i^{th} block in t^{th} year.

We used two dummy variables one for the BIMARU states and the other for North-eastern states of India.

1.6. Limitations of the Study

As the study is entirely based on both time series and cross-sectional secondary sources of data obtained from different published sources, authentic sources have been chosen without any personal bias. However, the limitations inherent in the secondary data are to be recognized. In some cases, correlation coefficients have been calculated based on cross sectional data on the variables from close but different years due to non-availability of data for the same year which might have affected the results up to some extent. In some cases correlation coefficients were found to be statistically significant between two variables and concluded that one causes the other. Significant correlation coefficients are not necessarily a proof for cause-effect relationships and therefore they have their own limitations. However, theoretical base or economic reasoning were supplied in such cases. Wherever the study uses annual time series data, the lesser number of observations in the pre and post reforms period acts as a limiting factor. Lack of strictly comparable data on some variable (poverty ratio, forest cover, etc.) due to methodological changes between two years was also a major limitation of the study.

1.7. Scheme of the Study

Taking into consideration the nature of poverty-environment nexus the present work has been planned in the following sequence:-

The whole thesis is divided into eight chapters. The first chapter is 'Introductory' which states the relevance and need of the study in Indian context, and outlines the objectives, hypotheses to be tested, database used, and methodology adopted in the study. Second chapter makes an in-depth study of review of literature. Third chapter analyses the economic growth, inequality and poverty in India in the pre and post reform period. Fourth chapter discusses the relationships between population, poverty and education. Trends in India's environmental status has been analysed in Chapter five. Sixth chapter is the core of the thesis under which the population-poverty-environment nexus and impact of environmental degradation on poor in India have been discussed in detail. The last chapter i.e., chapter eight summarises the findings with concluding observations and suggestions have been made for taking policy measures.

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CHAPTER-II

POVERTY-ENVIRONMENT RELATIONSHIPS: A LITERATURE REVIEW

Past studies pave the way for future research endeavor. An acquaintance with earlier pertinent studies has been felt necessary in order to identify the unexplored part of the earlier studies, to develop a better understanding of the problem under present study and to formulate an appropriate research methodology in the light of understanding of the tools adopted by the earlier studies. Hence, an attempt has been made in this chapter to review some of the previous studies on the relationships between poverty and environment. We review the studies undertaken in India as well as the studies conducted outside India to have an idea about the methodologies being adopted, their findings and limitations.

Many studies have established the link between poverty and environment by analyzing the dependence of rural households in developing countries on the natural resources – especially the common property or open access resources. Such studies have been done using data from India (Rao, 1994; Jodha, 2000; Narain, Gupta and Veld, 2005), Zimbabwe (Cavendish, 2000), Peru (Escobal and Aldana, 2003). Other studies have analyzed the effect of poverty or income levels of rural households on the resource management practices or environmental degradation in developing countries like Chile (Bahamondes, 2003), Peru (Swinton and Quiroz, 2003; Escobal and Aldana, 2003), Cambodia and Lao PDR (Dasgupta, et al., 2003), Guatemala and Honduras (Nelson and Chomitz, 2004). Most of these studies have

focussed on forest as the measure of environment; a few studies have also analyzed various other aspects of environmental degradation like fragile soil, water quality, indoor and outdoor air pollution. There are several limitations of these above-mentioned studies. Most of these focus on the effect of poverty on environment or infer about the other direction of relationship on the basis of extent of dependence of rural households on natural resources. And more importantly none account for the joint endogeneity of environmental change and change in poverty-that is crucial for testing the poverty-environment nexus hypothesis.

The relationship between poverty and environment has been analyzed in the literature mostly by descriptive and empirical studies. Ikefuji and Horii (Working paper, 2005) is the only study that provides a formal dynamic mathematical model to depict the poverty-environment trap. They showed that the income distribution played a crucial role in shaping the poverty-environment relationship. Rao (1994) inter-related the five themes viz., agricultural growth, rural poverty, environmental degradation, participatory rural development, and economic reforms in relation to agriculture. He concluded that growth and poverty interacted with environment in complex ways, each affecting the other.

A similar study was carried out by Manikkumaran (1997) in the state of Tamil Nadu. He examined data from 1960-90 and found that the agricultural growth is inversely related to rural poverty and directly related to environmental quality in the state of Tamil Nadu.

Agarwal (1997) analysed the interrelationships between gender poverty and the environment in rural India, focusing on regional variations and temporal shifts over 1971-91. Briefly identifying the major factors underlying environmental degradation, the study traced why and how this degradation and the appropriation of natural resources by the state (statization) and by some individuals (privatization) tended to have particularly adverse implications for the female members of poor rural households.

The interrelationships between poverty, environment and development are quite complex and amenable for easy generalization. There is a widely held view particularly in the West, that the poverty is the main cause of environmental deterioration, because the poor are not in a position to use natural resources sustainably (Duraippah, 1996; Prakash, 1997). The degradation in turn, it is believed leads to aggravation of poverty.

Nadkarni (2000) observed that the poor are perceived as having a short-time horizon, discounting the future benefits from conservations rather heavily owing to the urgency to make a livelihood and avoid hunger. Such a time horizon leads to unsustainable use of natural resources.

Prakash (1997) found that poor farmers put in a tremendous amount of planning and labour into building and maintaining terraced fields, controlling soil erosion, nurturing tree species for fuel, fodder and soil fixing and intricate soil and engineering mechanisms responsible for conserving, harvesting and distributing irrigation water. When the poor appear to degrade the environment, it is basically

due to lack of incentives and appropriate institutions, including lack of clarity on property rights.

Jodha (1986) defined CPRs as "the resources accessible to the whole community of a village and to which no individual had exclusive property rights. In the dry regions of India, they included village pastures, common forests, waste lands, common threshing grounds, waste dumping places, watershed drainages, village ponds, tanks, rivers/rivulets and river beds, etc." The study concluded that there is not a single but multiple factors attributed for the marginalization of the use of CPRs (Jodha, 1986, 1990; Iyengar and Shukla, 1999; Iyengar, 1998; Agarwal, 1997; Pasha, 1992).

Beck and Ghosh (2000) estimated roughly that the CPRs currently add some US $ 5 billion a year to the incomes of poor rural households in India, or about 12 % to household income of poor rural households.

Despite the dominant view in the literature that poverty causes environmental degradation, there is some contradicting empirical evidence. Some studies showed that traditional communities had managed the resources efficiently despite their poverty (Triffen, Mortimore and Gichuki, 1994) while others showed that it was not the poor but the non-poor population that depleted the rural environment (Ravnborg, 2003). Hence, the effect of poverty on environment is an empirically testable issue. Duraiappah (1996) analysed critically the existing literature on the poverty-environmental degradation nexus and tried to make "some order out of the chaos" inherent in this complex and difficult subject. A conceptual

framework of environmental degradation-poverty nexus was also provided. He found that conflicts between different user groups of natural resources, especially from different income groups in many cases caused agents to adopt unsustainable practices. This, in turn, marginalized some of the groups which eventually fell into the poverty trap. The conflicts to a large extent were either initiated or encouraged by institutional or market failure. Certain groups benefited while others suffered. Unsustainable use of natural resources inevitably caused poverty (endogenous poverty).

Arnold and Bird (1999) argued that poverty was not the main cause of deforestation since some of the most extreme deforestation took place during economic boom periods, often at the expense of the rural poor who lost access to land or a reduction in wage earning opportunities as labour saving machinery was utilized.

In an essay Boyce (1994) advanced two central hypotheses:

(1) The extent of an environmentally degrading activity depends on the balance of power between the winners, who derive net benefits from the activity, and the losers who bear net costs. When the winners are powerful relative to the losers, more environmental degradation occurs than in the reverse situation. This reflects the operation of a power-weighted social decision rule:

(2) Greater inequalities of power and wealth lead to more environmental degradation for three reasons:

(a) The excess environmental degradation driven by powerful winners is not offset by the environmental degradation prevented by powerful losers;

(b) Inequality raises the valuation of benefits reaped by rich and powerful winners relative to costs imposed on poor and less powerful losers;

(c) Inequalities raise the rate of time preference applied to environmental resources by both the poor and the rich, by increasing their poverty and political insecurity, respectively.

Both the hypotheses can be tested in empirical research. If accepted, they imply that democracy and equality are important not only as ends in themselves, but also as means to environmental protection.

Dilys and Elliatt (2005) offered a conceptual framework to understand poverty-conservation linkages. They argued that all of humanity is dependent on biodiversity for the goods and services it provides, but the poor were particularly dependent on it. Poverty contributed to biodiversity loss, but it was only one of a number of factors. Whether poor people conserve or over-exploit biodiversity is dependent on specific circumstances and contexts and particularly on the influence of external governance factors and not a question to which a generalized answer can be given.

The impacts of conservation activities are not evenly spread. Some forms of conservation activities may have negative consequences for the poor people. Others may benefit poor people or even be initiated by poor people.

Mukhopadhaya (2005) estimated the industrial emission of CO_2, SO_2 and NO_2 in India and sources of change was investigated. In addition, it also examined the sources of change of CO_2, SO_2 and NO_2 in India generated by different income groups especially by the lower income groups. The paper used input-output Structural Decomposition Analysis (SDA). Extension of the model incorporating different income groups was done. The study covers the period of 80s and 90s.

He found that the contribution made in overall emission by lower income groups was not significant but the higher income groups dominated for all emissions and almost for all factors. The environmental threats facing the poor people tend to be more directly hazardous to human health. Pollution related health hazards affect the lower income group people more than upper income group.

The environmental sustainability issues were reviewed (World Bank, 2001) based on extensive examination of documents and evaluations of IDA's environmental activities, interviews with staffs and managers, a survey of environmental task managers, and visits to selected countries.

It was observed that the poor generally suffered most from environmental problems and, therefore, improving the environment is intimately related to reducing poverty. The poor would benefit most from improved environmental conditions and more sustainable access to resources. But the poor could also cause environmental damage in their efforts to survive as they were most dependent on natural resources.

Most of the case studies analysed by Lopez (1992) appeared to support the hypothesis of subsistency of the poor combined with open access to resources for large scale agriculture, logging and other activities as a key factor in resource degradation.

Kates and Haarmann (1992) reviewed approximately 30 case studies considering the relationships between development and the environment in Asia, Africa, and Latin America. Their major conclusion was that the key source of rural environmental degradation was the disruption of the traditional institutions of the poor, which until recently had permitted an efficient and sustainable use of resources. The collapse of traditional systems led to a vicious cycle of environmental degradation and further impoverishment. Communities were originally poor, but had sufficient means to satisfy their basic needs and the maintenance of their environmental factors. After the institutional collapse they became desperately poor, unable to satisfy even their basic needs.

Cropper and Griffiths (1994) examined the effect of price of timber, population density and rate of growth of income on deforestation in 64 developing countries. They estimated the relationships using pooled cross-section and times-series data for each of Africa, Latin America, and Asia for the period 1961-1988. They found that while increase in price of timber, and population density increased rate of deforestation, increase in rate of growth of income reduces it.

Chaudhry (1995) examined the impact of population growth and economic development with reference to the conjectured global warming between 1991 and

2100 with special reference to India. He concluded that any rapid decline in the population projection for India over the next two decades would result in a considerable environmental improvement in the long-run.

Cavendish (2000) empirically analysed the poverty environment relationship in Zimbabwe and showed that environmental resources made a significant contribution to average rural incomes and that poor households were more resource dependent than were the rich.

Barbier and Burgess (1997) showed that the demand for forest conversion was negatively correlated with income per capita.

Bahamondes (2003), in a panel data study examining how asset levels affect the choice of agricultural practices and how practices affect natural resource status in arid central Chile, found that higher average wealth improves the environment, or, equivalently, that poverty causes environmental degradation.

Based on data from 502 households in 21 Indian villages, Jodha (1986) found that poor rural households derived on an average between 9 % and 26 % of their annul income from common-property natural resources while relatively rich households derived only between 1 % and 4 % of their annual income from the CPRs.

Reddy and Chakravarty (1999), based on data from 232 households in 12 Himalayan villages, similarly found that dependence on CPRs decreased from 23 % for the poor to 4 % for the rich.

Adhikari (2003), based on data from 330 households in 8 "forest user groups in Nepal, found that dependence increases with income, from 14 % for the poor to 22 % for the rich.

In a Study, Chowdhury and Sarwar (2008) investigated the relationship between poverty and deforestation in Tangail Division of Bangladesh using site visits, interviews, and a small questionnaire survey. He used a logit analysis using the binary data from the survey questionnaire. The results indicated that that contrary to common beliefs, in general, poor people in the study area are not the agents of environmental degradation. Depletion and degradation of forest resources are caused by encroachers (who are usually powerful and rich) and to some extent by the Forest Department staffs who do not have the skill, will, or resources to protect and conserve forest resources. The findings were based on a survey of 160 randomly selected households in the study area.

Shafik (1994) in his study found that environmental indicators improved with rising incomes (like water and sanitation), others worsened and then improved (particulates and sulfur oxides) and others worsened steadily (dissolved oxygen in oxides, municipal solid wastes, and carbon emissions). The turning points, at which the relationship with income changed, varied substantially across environmental indicators.

Baland, et al. (2003) examined linkages between alternative measures of poverty and collection of forest firewood by rural households in Nepal in the World Bank 1995-96 Living Standards Measurement Survey. The paper examined the link

between living standards and collection of forest firewood on the basis of household level evidence in rural Nepal from the 1995-96 Living Standards Measurement Survey (LSMS).They found no evidence that increases in consumption were associated with a reduction in firewood collection, irrespective of whether they control for household size, education, occupation or productive assets owned. Increased consumption was associated with a positive, concave wealth effect, with no significant effect on shadow cost of time in collecting firewood. However, controlling for consumption levels, collections were significantly lower for households of smaller size, more primary schooling, more non-farm employment and business assets.

Barros, Mendonca and Nogueira (2002) used models involving dichotomous response variables to investigate if social and economic indicators - mainly income and education- affect the environmental demand and consequently the environmental Kuznet's curve (EKC). It was inferred from the results that increases in education level and of some social indicators can generate higher probabilities of changes on individual demand for environmental goods and services. These results can be disaggregated into three interesting findings: (i) the Brazilian social problems - represented by low levels of education and of income-has affected demand for environmental goods and services and, consequently, the EKC; (ii) the direct relationship between poverty and environmental degradation, as some international institutions have tried to stand out, does not seem to be so consistent; investments on education and on some basic services would increase demand for environmental goods and services even among the poorest sections of society; and (iii) investments on social areas could guarantee an economic

growth with low levels of environmental degradation, generating a "tunnel" in the EKC.

Grimble, Cardoso and Chowdhury (2002) examined the nature of the linkages between rural poverty and the environment in developing countries, with particular respect to the causes of degradation and approaches to its mitigation. It also considered gaps in knowledge, research needs and policy implications for environmental management and poverty reduction. In so doing, a conceptual framework was developed for more generally guiding understanding of the environment-poverty nexus in rural situations.

The study observed that poverty and the environment in developing countries were closely related, the relationship was found to be complex and multifaceted, and lines of causation were variable and complex. Numerous examples of poor people acting in an environmentally sustainable manner indicated that poverty did not necessarily or even usually led to degradation nor, indeed, did poverty alleviation always led to environmental improvement. There was found little evidence to suggest that poor people discounted the future more highly than others in society and in favorable circumstances poor people as much as the non-poor took a long-term view of the environment. It was further argued that the wealthy by definition consumed more resources and created more waste than did the poor, and in the long run it might be these factors that had the greater global significance.

Bhattacharya and Innes (2006) presented an empirical study of population growth and environmental change using cross-section district-level data from South, Central and West India. Environmental change is measured using a satellite image based vegetation index. Unlike prior work, the analysis treated population and environmental change as jointly determined, distinguished between rural and urban populations, and distinguished between two components of population growth, natural population growth and migration. Among key findings are that environmental decline spurs increased rural natural population growth and increased net rural in-migration, which in turn prompt further environmental decline; environmental improvement spurs increased urban natural population growth and increased net urban in-migration; and environmental scarcity spurs environmental improvement.

A mutual link between poverty and environmental degradation was examined by Ikefuji and Horii (2005) in an overlapping generation's model with environmental externality, human capital, and credit constraints. They found that environmental quality affected labor productivity and thus wealth dynamics, whereas wealth distribution determined the degree to which agents relied upon natural resources and therefore the evolution of environmental quality. This interaction created a 'poverty-environment trap' where a deteriorated environment lowered income, which in turn accelerated environmental degradation. They also showed that greater wealth heterogeneity was the key to escaping the poverty-environment trap, although it had negative effects both on the environment and output when not in the trap.

Mariara (1992) investigated the relationship between rural poverty, property rights, and environmental resource management in a semi-arid region of Kenya using survey data. They hypothesized that reduced environmental degradation will increase agricultural productivity, which translates into lower levels of poverty as incomes and consumption expenditures rise; and that the quality of the environment and thus productivity and poverty are unaffected by property right regimes. They used a combination of probit and robust regression methods to derive the parameter estimates of their models. The results implied that poverty was associated with higher levels of environmental degradation, well-specified property rights are associated with higher productivity and lower poverty and that environmental conservation is an important mechanism for escaping poverty.

Using purpose-collected survey data from 537 households in 60 different villages of the Jhabua district of India, Narain, Gupta and Veld (2005) in their study investigated the extent to which rural households depended on common-pool natural resources for their daily livelihood. First, for the sub-sample of households that used positive amounts of resources, they found that dependence follows a U-shaped relationship with income, declining at first but then increasing. Second, they found that the probability of being in the sub-sample of common-pool resource users followed an inverse U-shaped relationship with income: the poorest and richest households were less likely to collect resources than those with intermediate incomes. Resource use by the rich was therefore bimodal: either very high or—for the very richest households—zero. Third, they found that resource dependence increased at all

income levels with an increase in the level of common-pool biomass availability. The combination of these results suggested that the quality of natural resources mattered to a larger share of the rural population than had been previously believed; common-pool resources contribute a significant fraction of the income not just of the desperately poor, but also of the relatively rich.

Dasgupta (2000) in his study concluded that the poorest countries were in great part biomass-based subsistence economies. Much labour is needed even for simple tasks. Moreover, households in great numbers do not have access to the sources of domestic energy available to households in advanced industrial countries. Nor do they have water on tap. In semi-arid and arid regions water supply is often not even close at hand nor is fuel-wood near at hand when the forests recede. This means that the relative prices of alternative sources of energy and water faced by rural households in poor countries are quite different from those faced by households elsewhere. In addition to cultivating crops, caring for livestock, cooking food and producing simple marketable products, household members may have to spend as much as five to six hours a day fetching water and collecting fodder and wood. These are complementary activities. They have to be undertaken on a daily basis if households are to survive. Each is time-consuming. Labour productivity is low not only because capital is scarce, but also because environmental resources are scarce. From about the age of 6 years, children in poor households in the poorest countries mind their siblings and domestic animals, fetch water, and collect fuel wood, dung (in the Indian sub-continent), and fodder. Mostly, they do not go to school. Not only

are educational facilities in the typical rural school woefully inadequate, but parents need their children's labour.

Jodha (1986, 1995) studied evidence from over 80 villages in 21 dry districts in India to conclude that, among poor families, the proportion of income based directly on their local commons is for the most part in the range 15-25 percent. A number of resources (such as fuel wood and water, berries and nuts, medicinal herbs, resin and gum) are the responsibility of women and children.

In a study of 29 villages in south-eastern Zimbabwe, Cavendish (1998, 1999) arrived at even larger estimates: the proportion of income based directly on the local commons was 35 percent; the figure for the poorest quintile was 40 percent. Such evidence did not of course prove that the local commons are well-managed, but they suggested that rural households had strong incentives to devise arrangements whereby they would be well-managed.

Scott (2006) examined the link between certain agricultural practices and natural resource sustainability. In the impoverished setting of the Peruvian Altiplano, soil nutrient loss and erosion were diminished by the use of fallow and, in some cases, by the use of vertical furrows. Overgrazing was reduced by rotational grazing. With the direction of causality unclear, overgrazing was also positively associated with decreases in herd size.

The three agricultural practices with clear natural resource impacts require either land (for fields in fallow rotation) or labor (for tillage or rotational grazing).

None requires much investment capital. So it should not be surprising that fixed capital variables had little ability to explain adoption of these methods.

By contrast, deforestation in this area is chiefly caused by the search for fuel wood. Not cutting wood carries the financial opportunity cost of buying some other fuel for cooking and heating. As a result, the households poorest in land ownership, access to credit and community lands, schooling, and access to roads were those most likely to timber native forests.

Swinton and Quiroz (2003) examined links between poverty and natural resource degradation in the context of soil erosion, fertility loss and over-grazing in the Peruvian Altiplano. Multiple regression analysis of 1999 farm survey data examined: (1) what agricultural practices affect natural resource degradation, and then (2) what factors affect farmers' choices of those agricultural practices. Soil erosion and fertility loss appear reduced by increased fallow in crop rotations. Overgrazing and range species loss are affected by changes in herd size and rotational grazing. The effect of investment poverty on natural resource outcomes is not clear. However, social and human capital variables both tend to favor the choice of more sustainable agricultural practices. Natural resource conservation policies that build on traditional social institutions may offer promise in areas with strong social fabric where farmers tend not to invest financially in natural resource conservation.

Khan (2007) investigated the linkages between Poverty, environment and economic growth and the existing evidence for Pakistan and other countries. The paper used secondary data and information to probe into these linkages. The study

found that 'poverty leads to environmental degradation' was a common belief but it was not clearly supported by evidence. What is more strongly supported by evidence is the fact that environmental degradation hurts more the poor. It has been showed that low income groups are the most affected when environmental degradation occur, but not enough information available in Pakistan on the mechanisms.

A study by Markandya (1998) dealt with the key distributional issues arising from the regulation of the environment and the management of natural resources. The study concluded that although there was much discussion of the linkages of poverty to environmental degradation, empirical studies establishing these linkages were few. The relationship is critically dependent on the institutional structures in the countries concerned and how they respond to changing environmental pressures. On the broader distributional impacts, the papers focused on the analysis of gainers and losers from environmental regulations.

In an article Sobhee (2004) examined how environmental degradation of fisheries resources in the context of Mauritius was linked up with human investment in education, economic growth, and income inequality. Empirical evidence showed that public sector investment in education promoted economic growth, but at the expense of greater inequality of income. Among the vulnerable groups affected by this type of development process lies the fisherman community. In fact, children of poor families in coastal Mauritius have constrained access to complete school education because of the persistently high opportunity cost involved. Hence, this community is caught up in

a vicious circle, as its children or grandchildren would barely be redeployed elsewhere other than in the fisheries sector itself. Such exclusion might account for the over-exploitation of marine resources of the island and the accompanying reduction in fish catch over recent years.

Khan, Inamullah and Shams (2007) in their study explored the inter-linkages among population, environment and poverty and presents empirical evidence in a developing country like Pakistan. It explained poverty trap, market based harmony, and dual effect of poverty on the basis of a link between population growth and natural resource degradation. It also presented empirical evidence on population-environment-poverty nexus in Pakistan. The paper concluded that the causal relationship between poverty and environment worked in both directions, often through changes in GDP and population. Population stress did not have any significant direct effect on all.

Mukherjee and Kathuria (2006) in their study attempted to investigate the relationship between Environmental Quality (EQ) and per capita NSDP (i.e., Environmental Kuznets Curve, EKC) of 14 major Indian States, in the light of their high economic growth in the post-liberalisation period. The analysis involved first ranking the States on the basis of their EQ, and then checking the relationship. The results indicated that the relationship between EQ and per capita NSDP was slanting S-shaped. Except Bihar, all the States were on the upward sloping curve of the EKC. The results suggested that the economic growth is mostly at the cost of EQ.

Concluding Remarks

There are several limitations of the previous studies reviewed above. Most of these studies focus on the effect of poverty on environment or infer about the other direction of the relationship on the basis of extent of dependence of poor on natural resources. The relationship between poverty and environment has been analyzed in literature mostly by descriptive and empirical studies. The above review of the previous studies reveals that there is a complex causal relationship between poverty and environment. There is a two-way causal relationships between poverty and environmental degradation, i.e., poverty causes environmental degradation and vice verse. But these relationships are often found to be indirect. Moreover, it does not imply that the rich do not cause the environment to degrade. In fact, whether the environmental degradation is caused by the rich and powerful or by the poor depends on the nature of environmental degradation. While the rich as well as the poor could be the agent for environmental pollution, the adverse impact of it is disproportionately on the poor due to their dependency on natural resources for income, employment and livelihoods.

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CHAPTER-III
ECONOMIC GROWTH, INCOME DISPARITIES AND POVERTY IN INDIA
A comparative Analysis of Pre and Post-reform Period

3.1. Introduction

Although higher economic growth alone does not ensure decline in poverty, it is still considered a powerful instrument in the hands of the government for the removal of poverty. The higher economic growth provides the government the opportunity to not only promote developmental activities in a more comprehensive way but also undertake direct measures for poverty alleviation and employment generation programmes at large scale. Exactly this has happened in India in the post-reform period. The Indian economy attained a higher growth trajectory in the post-reform period. As a result of which, poverty in India at national level in terms of head count ratio has substantially declined in the post-reform period as compared to that in the pre-reform period indirectly through the working of trickle-down effect and directly through launching of different programmes to alleviate poverty and generate employment facilitated by higher economic growth achieved in the post-reform period. However, the impressive growth achieved in the post-reform period alone does not ensure that all the Indian states, irrespective of their socio-economic status, have also equally been benefitted on socio-economic fronts. It is quite possible that in spite of higher growth, the pattern of growth could not have been conducive to alleviation of poverty equally across states. It is also likely that the rich states may have benefited largely from the economic reforms as they were

better equipped with socio-economic infrastructures and the poor states because of poor infrastructural facilities lagged behind.

At the end of our detailed analysis, our objectives are to answer some of the questions which are relevant to our present study like whether India has experienced structural shift in economic growth as a result of the economic reform?. What are the implications of changing pattern of growth for the poor? Whether India has succeeded in translating the higher economic growth achieved during post-reform period into poverty reduction effectively? Has the economic reform resulted in increased income disparity between the rich and the poor states?

3.2. Previous Studies on Inequality and Poverty across Indian States

Different researchers have differing views regarding the impact of the economic reforms on growth, inequality, poverty and unemployment in India. Dev and Ravi (2007) analysed the data over the period 1983-2005 and showed that in spite of higher overall growth the extent of decline in poverty in the post reform period (1993-2005) had not been higher than in the pre-reform period (1983-1993). They also concluded that inequality increased significantly in the post-reform period which slowed down the rate of poverty reduction. In yet another study, Dev (2000) examined the impact of economic reforms on poverty, income distribution and employment. He found that in the post-reform period, rural poverty reduction had been arrested but urban poverty recorded a significant decline in the 1990s, the inequalities in consumption distribution was higher in the post-reform period as compared to pre-reform period, and the quality of employment declined. Dholakya (2003) in his study found that while per capita income did not show any significant

trend in regional disparity over the period 1981-2001, seven out of nine human development indicators displayed a declining trend and 12 of the 16 related social and human development indicators showed a marked decline in regional disparity during 1981-91. Deaton and Dreze (2002) presented a new set of integrated poverty and inequality estimates for India and Indian states for 1987-88, 1993-94 and 1999-00. They showed that poverty declined in the 1990s proceeded more or less in line with earlier trends. Regional disparities increased in the 1990s, with the southern and western regions doing much better than the northern and eastern regions. Economic inequality also increased in and within states and, especially within urban areas and between urban and rural areas. Bhalla (2003) concluded that, in particular, in the light of data from the national sample surveys, poverty in India was less than 15 percent in 1999-00 which was nearly half the official government of India estimate of 26 percent. An econometric model of poverty incidence was calibrated by Datt, Kozel and Ravallion (2003) to 20 household surveys for India's 15 major states spanning 1960-1994. The model built on past research suggested that the key determinants of the rate of poverty reduction at state level were agricultural yields, growth of the non-farm sector (depending on the state's initial conditions) development spending, and inflation. It further suggested that the rate of poverty reduction in the 1990s was slightly lower than the 1980s, and lower than one would have expected given the growth in the 1990s. Jha and Sharma (2003) presented evidence on the poverty experiences of 75 NSS regions for the quinquennial rounds of 1987-88, 1993-94 and 1999-00. They found wide variation within states, particularly, but not exclusively, the larger states ones. Furthermore,

regional inequality in the incidence of poverty was found to have persisted over time and the economic reforms program was unable to make any significant dent on the spatial distribution of incidence of poverty. A study by Datt and Ravallion (2002) led them to conclude that India maintained its 1980s rate of poverty reduction in the 1990s. Their investigation also emphasized the considerable diversity in performance across states. Their results suggested that, by and large, the (farm and non-farm) growth in India during the 1990s had not been occurring in the states where it would have had the most impact on poverty nationally. They further concluded that there were large differences across states in the poverty impact of any given rate of growth in non-agricultural output. States with relatively low levels of initial rural development were not well suited to economic growth. Jha (2000) examined the empirical relationship between economic growth, inequality and poverty in the Indian states using NSS data on consumption for the 13^{th} to the 53^{rd} Rounds. The rank concordance index across states did not usually show convergence. Nevertheless, there was found to be conditional convergence (in terms of levels) in inequality and poverty measures across states.

Bhalla (2000) found that poverty fell far more rapidly in the 1990s than previously. Sen (2001) argued that poverty reduction in India stalled in the 1990s and it might have even risen. Using the Planning Commission's (2001) official poverty lines, Deaton (2000a) found that the rural poverty rate fell from 37.2 percent in 1993-94 to 30.2 percent in 1999-00, while the urban poverty fell from 32.6 percent to 24.7 percent. Sundaram (2001) analysed the consumption distribution from the Employment–Unemployment Surveys and found that annual

rates of poverty reduction were 0.50 points per year for rural areas and 0.27 points per year for urban areas.

3.3. Trends in Some Growth Aggregates in India

Net National Product at factor cost (NNP at factor cost) is deemed to be a good indicator of overall economic performance of an economy. A look at the following table (Table: 3.1) reveals that the NNP at factor cost has been growing in both pre and post reform period. The annual compound growth rate rose from 4.60 percent in the pre-reform to 6.29 percent in the pos-reform period. There has also been a structural change in its growth over the two periods. A test of structural stability was conducted using the dummy variable technique.

Table: 3.1
Net National Product (at factor cost) in the Pre-reform and Post-reform Period (At constant prices)

(In Rupees crore)

Year	NNP	Year	NNP
1977-78	547415	1992-93	1024459
1978-79	577567	1993-94	1084704
1979-80	543172	1994-95	1155025
1980-81	583256	1995-96	1239511
1981-82	615217	1996-97	1342048
1982-83	629073	1997-98	1399791
1983-84	679766	1998-99	1493000
1984-85	704080	1999-00	1585501
1985-86	732513	2000-01	1643998
1986-87	762716	2001-02	1739876
1987-88	785726	2002-03	1801430
1988-89	866345	2003-04	1959599
1989-90	919071	2004-05 P	2103350
1990-91	963615	2005-06 QE	2295243
1991-92	972145	2006-07 RE	2522576
Mean	725445	Mean	1626007
C.V.	20.54	C.V.	27.56
ACGR	4.60 (22.337*)	ACGR	6.29 (44.695*)
Result of Dummy Variable Technique for the Test of Structural Change			
Differential Intercept	0.252 (5.867*)		
Differential Slope Co-efficient	-0.016 (-6.721*)		R^2=0.997

Note: The values in parentheses are respective t-values; * Indicates that the t-value is significant at 1% level.
Source: Central Statistical Organization, Government of India.

It was found that both the differential intercept and differential slope coefficient had changed significantly at 1 percent level of significance. The coefficient of variation is slightly larger in the second period than in the first period indicating that the growth in the NNP at factor cost has been relatively smooth in the pre-reform period.

Economic growth as reflected in national income (measured by NNP at factor cost also) is important for poverty alleviation and income generation but more important is the growth in its sectoral component. In India, the poor are largely dependent on agriculture and allied sectors. More than 60 percent of the

Table: 3.2
Components of Gross Domestic Product (at factor cost) during Pre-reform and Post-reform Period
(1999-00 series)

Pre-reform Period (1977-78 to 91-92)				
Year	Agriculture & allied	Agriculture	Industry	Service
1977-78	241646	218172	101219	254546
1978-79	247210	222520	112569	267828
1979-80	215630	192788	109864	271303
1980-81	243421	220624	112002	286499
1981-82	254622	231320	121997	301413
1982-83	253907	230997	127645	316309
1983-84	279605	255837	139098	333966
1984-85	284037	259633	145294	353153
1985-86	284930	260139	150992	379128
1986-87	283763	259122	161250	405204
1987-88	279257	254647	170277	430732
1988-89	322932	297543	186578	460192
1989-90	326773	298720	202947	499459
1990-91	339893	311500	214552	529127
1991-92	333256	304301	213925	551890
Mean	279392.1	254524.2	151347.3	376049.9
C.V.	12.85	13.50	23.87	23.82
ACGR	2.84 (9.422*)	3.05 (9.329*)	5.76 (28.147*)	5.97 (37.808*)

(Contd.)

people living below poverty line who mainly depend on agriculture for their income and employment belong to rural areas of India. Therefore, for the poor in

India it is the growth of agriculture and allied sectors that matters more than the growth in any other sectors.

Components of Gross Domestic Product (at factor cost) during Pre-reform and Post-reform Period
(1999-00 series) **(Contd.)**

Post-reform Period (1992-93 to 2005-06)				
1992-93	355421	325777	220880	581723
1993-94	367231	336136	237376	619209
1994-95	384549	352069	262164	655363
1995-96	381875	348626	296664	718434
1996-97	419759	384886	320266	768353
1997-98	409039	373446	326720	837504
1998-99	434892	400030	338369	905148
1999-00	446515	409660	350233	989778
2000-01	445594	407368	372599	1046578
2001-02	473530	433756	381366	1118016
2002-03	439321	398560	407276	1201136
2003-04	483274	441958	431724	1307593
2004-05 P	483080	441124	467896	1438684
2005-06 QE	512147	468953	505485	1586900
Mean	431159.1	394453.5	351358.4	983887.1
C.V	11.02	11.01	23.81	32.04
ACGR	2.63 (12.857*)	2.53 (11.670*)	5.97 (20.825*)	7.90 (77.901*)
Results of Dummy Variable Technique for the Test of Structural Change				
	D.I	D.S.C	R^2	
Agriculture & allied	-0.084 (-1.252^)	0.002 (0.667^)	0.976	
Agriculture	-0.105 (-1.463^)	0.004 (1.022^)	0.973	
Industry	0.001 (0.025^)	-0.001 (-0.400^)	0.995	
Service	0.312 (9.203*)	-0.019 (-9.979*)	0.999	

Note: D.I and D.S.C denote Differential Intercept and Differential Slope Coefficients. The values in parentheses are respective t-values, * indicates that the t-value is significant at 1% level and ^ shows that it is not significant at 1 % level.
Source: Central Statistical Organization, Government of India.

Both the agriculture & allied and agriculture sectors registered a decline in annual compound growth rates (ACGR) in the post-reform period as compared to pre-reform period. But the reverse was the case with the industrial and service sectors in that these sectors grew at faster rates (in terms of ACGR) in the post-reform period. The ACGR of agriculture & allied and agriculture sectors were 2.84

percent and 3.05 percent respectively in the pre-reform period which declined to 2.63 percent and 2.53 percent respectively in the post-reform period. While the industry and service sectors growth rates were 5.76 percent and 5.97 percent respectively in the pre-reform period which rose to 5.97 percent and 7.90 percent respectively in the post reform period. There were found to be no structural changes in either differential intercepts or differential slope coefficients for agriculture & allied, agriculture, and industrial sectors over the two periods. But service sector experienced structural changes as differential intercept as well as differential slope coefficient were found to be statistically significant at 1 percent level (Table: 3.2).

Table: 3.3
Per Capita Net National Product (at factor cost) in the Pre-reform and Post-reform Period
(At constant prices) (Rupees crore)

Pre-reform		Post-reform	
Year	PCNNP	Year	PCNNP
1977-78	8634	1992-93	11748
1978-79	8913	1993-94	12160
1979-80	8180	1994-95	12693
1980-81	8590	1995-96	13357
1981-82	8890	1996-97	14187
1982-83	8885	1997-98	14521
1983-84	9402	1998-99	15188
1984-85	9527	1999-00	15839
1985-86	9702	2000-01	16133
1986-87	9893	2001-02	16762
1987-88	9971	2002-03	17075
1988-89	10762	2003-04	18263
1989-90	11181	2004-05 P	19297
1990-91	11485	2005-06 QE	20734
1991-92	11357	2006-07 RE	22483
Mean	9691	Mean	16029
C.V.	11.07	C.V.	19.66
ACGR	2.32 (11.285*)	ACGR	4.39 (28.765*)
Result of Dummy Variable Technique for the Test of Structural Change			
Differential Intercept	0.308 (6.845*)		R^2= 0.991
Differential Slope Co-efficient	-0.016 (-7.737*)		

Note: The values in parentheses are respective t-values; * Indicates that the t-value is significant at 1% level.
Source: Central Statistical Organisation, Government of India.

The ACGR in Per Capita Net National Product at factor cost (at constant prices) was only 2.32 percent during 1977-78 to 1991-92 (pre-reform period). The figure almost doubled to 4.39 percent during 1992-93 to 2006-07 (post-reform period). Test of structural stability showed that differential intercept as well as differential slope coefficient changed at 1 percent level of significance (Table: 3.3).

Table: 3.4
Population in the Pre-reform and Post-reform Period (In millions)

Pre-reform		Post-reform	
Year	Population	Year	Population
1977-78	634	1992-93	872
1978-79	648	1993-94	892
1979-80	664	1994-95	910
1980-81	679	1995-96	928
1981-82	692	1996-97	946
1982-83	708	1997-98	964
1983-84	723	1998-99	983
1984-85	739	1999-00	1001
1985-86	755	2000-01	1019
1986-87	771	2001-02	1038
1987-88	788	2002-03	1055
1988-89	805	2003-04	1073
1989-90	822	2004-05 P	1090
1990-91	839	2005-06 QE	1107
1991-92	856	2006-07 RE	1122
Mean	741.53	Mean	1000.00
C.V.	9.57	C.V.	8.04
ACGR	2.12 (300.020*)	ACGR	1.82 (74.859*)
Result of Dummy Variable Technique for the Test of Structural Change			
Differential Intercept	-0.045 (-10.234*)		R^2
Differential Slope Co-efficient	0.003 (9.699*)		0.999

Note: The values in parentheses are respective t-values; * Indicates that the t-value is significant at 1% level.
Source: Central Statistical Organization, Government of India.

The impressive growth in per capita net national product should not be attributed solely to the economic reforms of 1991. The slower ACGR in population in the post-reform period than in the pre-reform period inflated the ACGR in per capita net national product in the post-reform period. The population of India

increased at the rate of 2.12 percent ACGR during the pre-reform period. It decreased to 1.82 percent during the post-reform period. The trend in India's population witnessed structural changes between pre and post-reform period which is reflected through both the differential intercept and the slope coefficient (Table: 3.4).

3.4. Convergence or Divergence among Indian States during Pre and Post- Reform Period

A number of studies covering different time periods have examined whether per capita income levels have been converging or diverging in India. Most of the studies like ours found a tendency towards divergence rather than convergence.

Dholakia (1994) analyzing 20 Indian states over the period 1960-90 found marked tendencies of convergence of long-term State Domestic Product (SDP) growth rates Chashin and Sahay (1996) also reached similar conclusions as Dholakia. They found absolute convergence in a study of 20 states over the period 1961-91.

Rao, Shand and Kalirajan (1999), by contrast, suggested that per capita SDP in the Indian states had tended to diverge rather than converge. Per capita SDP was found to be positively related to their initial levels. Dasgupta et al. (2000) reported a distinct tendency for the Indian states to have diverged during the period 1960-95 as far as per capita SDP is concerned. Kurian (2000) found widening regional disparities among the Indian states and a clear dichotomy between what he called the forward and backward states. The former having higher levels of per capita

income, better infrastructure, higher per capita resource flows and private investment and better social and demographic indicators.

Ahluwalia (2001) analyzing the economic performance of the Indian states during the post-reform period suggested that not all the richest got richer relative to poorer states. He cited Punjab and Haryana as two key examples. While these were the two richest states in 1990-91, their growth rates of per capita SDP in the 1990s were not only lower than in the 1980s, but also in both states actually fell below the national average. He also pointed out that not all the poor states lagged behind. While suggesting that two poor states, Rajasthan and Madhya Pradesh had performed well, Ahluwalia did not offer an explanation for their better performance, however.

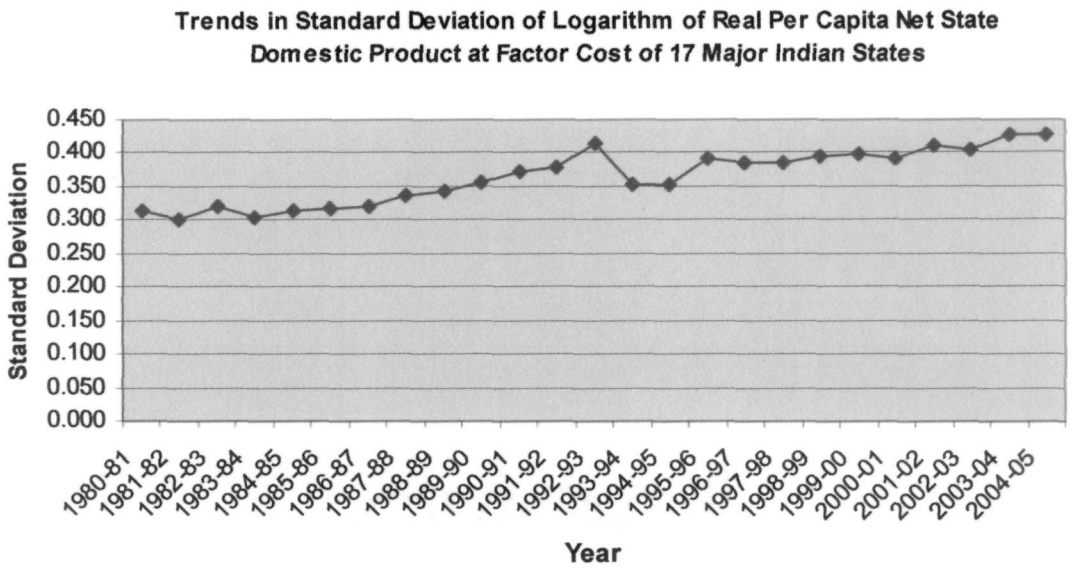
The conclusions of these studies differ according to which group of states is examined. Our findings which focus on the 17 most populous states find evidence of overall divergence rather convergence.

3.5. Testing Convergence among Indian States in Pre and Post-reform Period

There are two standard ways of examining the presence or absence of unconditional convergence (Barro and Sala-i-Martin, 1995). The first measure is the so-called σ-convergence. We measure the standard deviation across states of the logarithm of Per Capita Net State Domestic Product at factor cost (PCNSDP at factor cost) at constant prices. There is σ-convergence if the standard deviation across states tends to decline over time. The second measure is β-convergence. Under this measure, we regress the proportionate growth in Per Capita Net State

Domestic Product at factor cost (PCNSDP at factor cost) at constant prices on the logarithm of Initial Per Capita Net State Domestic Product at factor cost (IPCNSDP at factor cost) at constant prices. There is β-convergence if the co-efficient of initial income, denoted by β, is negative and statistically significant.

Figure: 3.1



The trends in standard deviation of logarithm of real per capita income have been shown in Figure: 3.1. The standard deviation has been constantly rising during the pre-reform period up to 1992-93. It fell for a brief period of two years thereafter it again started rising from 1994-95 onwards. It is, however, apparent from the figure that the rate of growth in the standard deviation was more in the pre-reform period than in the post-reform period. In other words, the Indian states were diverging at a faster pace in the pre-reform period which has somewhat slowed down in the post-reform period.

The regression results are as follows:

During the pre-reform period (1980-81 to 1992-93):

PG = -0.162 + 0.026 Ln (IPCNSDP)

Se	(0.086)	(0.012)
t	-1.890	2.269
Sig.	0.077	0.037

$R^2 = 0.243$, F = 5.149, Sig. 0.037, d = 2.038, n = 17

During the post-reform period (1993-94 to 2004-05):

PG = -0.101+ 0.016 Ln (IPCNSDP)

Se	(1.108)	(0.012)
t	-0.937	1.313
Sig.	0.363	0.045

$R^2 = 0.197$, F = 17.23, Sig. 0.008, d = 1.593, n = 17

The above results show that coefficients of initial income, βs, are not negative but positive and statistically significant at 5 percent level for pre as well as post-reform period indicating the absence of β-convergence among the Indian states during both pre-and post-reform periods. However, coefficient of initial income is more in the pre-reform than in the post-reform period. This leads us to conclude that although the divergence still continues, its severity has reduced in the post-reform period.

Out of the seventeen major states of India, eight experienced higher ACGR in their Net State Domestic Product at factor cost (NSDP at factor cost) and nine experienced lower ACGR in the post reform period than in the pre-reform period. Four out of six poorest states of India namely Madhya Pradesh, Rajasthan, Uttar Pradesh and Assam registered lower growth and the remaining two states namely

Bihar and Orissa registered higher growth in the NSDP in terms of ACGR in the post-reform period (Table: 3.5).

Table: 3.5
Annual Compound Growth Rate (%) of Net State Domestic Product (at factor cost) in Pre and Post-reform Period

	Pre-reform			Post-reform		
State	ACGR	t-Value	R^2	ACGR	t-Value	R^2
Andhra Pradesh	6.71	11.265	0.920	5.86	28.002	0.987
Assam	3.35	14.954	0.953	2.94	12.154	0.937
Bihar	3.76	8.014	0.854	4.71	11.562	0.930
Goa	6.61	10.189	0.904	6.72	7.058	0.833
Gujarat	4.81	7.149	0.823	5.76	10.099	0.911
Haryana	6.29	16.901	0.963	6.07	32.420	0.991
Himachal Pradesh	4.92	11.305	0.921	6.50	37.127	0.993
Karnataka	5.44	23.749	0.981	6.82	25.873	0.985
Kerala	3.66	8.679	0.873	5.23	23.954	0.983
Madhya Pradesh	4.08	11.106	0.918	3.97	10.755	0.920
Maharashtra	6.29	16.043	0.959	5.13	17.146	0.967
Orissa	3.56	6.500	0.793	4.39	9.751	0.895
Punjab	5.23	39.934	0.993	4.29	33.099	0.991
Rajasthan	6.50	9.848	0.898	5.76	8.886	0.888
Tamil Nadu	5.34	19.829	0.973	4.71	14.706	0.956
Uttar Pradesh	4.71	21.175	0.976	3.87	18.487	0.972
West Bengal	4.71	27.063	0.985	7.14	210.569	0.999

Note: All the t-values are significant at 1% level.
Source: Central Statistical Organization, Government of India.

Table: 3.6 depict the ACGR in Per Capita Net State Domestic Product at factor cost (PCNSDP at factor cost) in major states of India. Again eight out of seventeen major states registered higher ACGR and the remaining nine states registered lower ACGR in their PCNSDP at factor cost in the post reform period. But it is notable here that out of the abovementioned six poorest states, only two states namely Assam and Orissa experienced higher growth in PCSDP in the post reform period. The mean ACGR was 3.23 percent in the pre-reform period which slightly rose to 3.33 percent in the post- reform period.

Table: 3.6
Annual Compound Growth Rate (%) of Per Capita Net State Domestic Product (at factor cost) during Pre (1980-81to 92-93) and Post-reform (1993-94 to 04-05) Period

	Pre-reform (1980-81to 92-93)			Post-reform (1993-94 to 04-05)		
State	ACGR	t-value	R^2	ACGR	t-value	R^2
Andhra Pradesh	3.56	6.176	0.792	4.81	21.340	0.979
Assam	1.21	-4.489	0.668	1.31	5.563	0.756
Bihar	2.12	5.864	0.775	2.02	3.219	0.509
Goa	5.54	6.197	0.793	2.63	3.876	0.600
Gujarat	2.23	3.293	0.520	3.66	6.151	0.791
Haryana	3.97	9.680	0.905	3.56	16.542	0.961
Himachal Pradesh	2.94	5.764	0.769	4.71	27.944	0.987
Karnataka	3.45	11.842	0.933	5.34	20.822	0.977
Kerala	2.02	4.222	0.641	4.29	21.090	0.978
Madhya Pradesh	6.28	3.815	0.593	1.82	3.995	0.615
Maharashtra	3.56	8.851	0.887	3.15	10.328	0.914
Orissa	*2.02*	*3.172*	*0.502*	*3.05*	*6.561*	*0.812*
Punjab	3.35	22.436	0.981	2.53	24.357	0.983
Rajasthan	3.76	4.764	0.694	3.25	5.055	0.719
Tamil Nadu	3.87	11.386	0.928	3.66	11.839	0.933
Uttar Pradesh	2.53	10.686	0.911	1.41	6.812	0.823
West Bengal	2.42	11.917	0.934	5.45	195.481	0.999
Mean	3.23			3.33		
C.V.	40.00			38.86		

Note: All the t-values are statistically significant at 1% level
Source: Central Statistical Organization, Government of India.

The following Table: 3.7 depict the mean Per Capita Net State Domestic Product at factor cost (PCNSDP at factor cost) during pre and post-reform period. We have ranked the states on the basis of mean PCNSDP. State with highest mean per capita income was assigned rank 1 and state with lowest mean per capita income was assigned rank 17 in both pre and post-reform period. Then, we calculated the Spearman's rank correlation coefficient which comes 0.754. This shows a high degree of positive rank correlation. Hence, in the post-reform period, most of the states retained their pre-reform status in terms of mean per capita income.

Table: 3.7

Average Per Capita Net State Domestic Product (at constant prices) during Pre-reform (1980-81 to 92-93) and Post-reform (1993-94 to 2004-05) Period

State	Pre-reform		Post-reform	
	Mean PCNSDP	rank	Mean PCNSDP	rank
Andhra Pradesh	1705	10	9526	9
Assam	1461	13	5980	14
Bihar	1059	17	3349	17
Goa	3644	1	6864	13
Gujarat	2293	5	13285	4
Haryana	2852	4	13388	3
Himachal Pradesh	1895	7	10464	7
Karnataka	1808	9	10546	6
Kerala	1562	11	10237	8
Madhya Pradesh	1444	14	7368	12
Maharashtra	2888	3	14474	2
Orissa	1416	16	5620	15
Punjab	3267	2	14485	1
Rajasthan	1496	12	8251	11
Tamil Nadu	1832	8	11638	5
Uttar Pradesh	1440	15	5582	16
West Bengal	1952	6	9234	10
Rank Correlation Coefficient	0.75			

Source: Central Statistical Organization, Government of India.

Table: 3.8

Initial Per Capita Net State Domestic Product (at constant prices) and ACGR during Pre-reform (1980-81 to 92-93) and Post-reform (1993-94 to 2004-05) Period

State	Pre-reform (1980-81 to 92-93)		Post-reform (1993-94 to 2004-05)	
	Initial PCNSDP	ACGR	Initial PCNSDP	ACGR
Andhra Pradesh	1380	3.56	7416	4.81
Assam	1284	1.21	5715	1.31
Bihar	917	2.12	3037	2.02
Goa	3145	5.54	5897	2.63
Gujarat	1940	2.23	9796	3.66
Haryana	2370	3.97	11079	3.56
Himachal Pradesh	1704	2.94	7870	4.71
Karnataka	1520	3.45	7838	5.34
Kerala	1508	2.02	7983	4.29
Madhya Pradesh	1358	6.28	6584	1.82
Maharashtra	2435	3.56	12183	3.15
Orissa	1314	2.02	4896	3.05
Punjab	2674	3.35	12710	2.53
Rajasthan	1222	3.76	6182	3.25
Tamil Nadu	1498	3.87	8955	3.66
Uttar Pradesh	1278	2.53	5066	1.41
West Bengal	1773	2.42	6756	5.45
Correlation Coefficient	0.406		0.265	

Source: Central Statistical Organization, Government of India.

The correlation coefficients between initial per capita incomes and annual compound growth rates across states in pre as well as post-reform periods are again positive. However, its value has declined from 0.406 in the pre-reform to 0.265 in the post-reform. Thus, the initial income of a state also has a positive impact on its annual compound growth rate. The positive impact has weakened in the post-reform period, however (Table: 3.8).

In addition to the methods of σ and β convergences described above, we also formulate the following model for testing the presence or absence of convergence among the Indian states:

$$PG_i = \alpha_0 + \alpha_1 D_i + u_i$$

D = 1, for the states whose rank on the basis of initial per capita state domestic product is 8 or less than 8 (termed as rich states)

= 0, otherwise, that is, for the states whose rank is greater than 8 (termed as poor states).

PG denotes proportionate growth in i^{th} state. In both pre and post-reform periods, the state with lowest initial per capita state domestic product is assigned rank 17 and the state with highest initial per capita state domestic product is assigned rank 1.

The estimated models for pre and post-reform periods are as follows:

For pre-reform period:

PG = 0.024 + 0.016D		$R^2 = 0.255$
Se	(0.005) (0.007)	F = 5.466, Sig. 0.033
t	4.904 2.338	d = 2.121
Sig.	0.000 0.033	n = 17

For post-reform period:

PG = 0.035 + 0.010D			$R^2 = 0.088$
Se	(0.006)	(0.008)	F = 1.549, Sig. 0.231
t	5.936	1.245	d = 1.565
Sig.	0.000	0.231	n = 17

The dummy variable techniques used above for testing the convergence between the rich and the poor states of India in terms of proportionate growth in real per capita net state domestic product reveal that both the intercept and slope coefficient are statistically significant at 5 percent in the pre-reform period. Hence, the mean annual proportionate growth of the rich states is significantly higher than the poor states in the pre-reform period. The mean annual proportionate growth of the rich states and the poor states are 0.040 (or 4 percent) and 0.024 (or 2.4 percent) respectively in the pre-reform period.

During the post-reform period, the intercept is statistically significant at much below the 1 percent level but the slope coefficient is not significant at even 20 percent. This shows that the mean annual proportionate growth of the rich states is not significantly higher than the poor states in the post-reform period. The mean annual proportionate growth of the rich states and the poor states are 0.045 (or 4.5 percent) and 0.035 (or 3.5 percent) respectively in the post-reform period.

The positive slope coefficients in both pre and post-reform periods are evidences in support of the hypotheses that there is no convergence between the rich and the poor states in either pre or post-reform period. In other words, the rich

and the poor states were diverging during the pre-reform period and they continue to diverge during the post-reform period.

3.6. Economic Growth and Its Impact on Poverty

In order to know the impact of economic growth on poverty in India across states in pre and post reform period, we have estimated the poverty elasticities in both pre and post-reform periods as follows:

For pre-reform period:

$$\text{Ln (PR)} = 20.576 - 2.093\text{Ln (PCNSDP)}$$

Se	3.963	0.520
t	5.19	-4.02
Sig.	0.000	0.000

$F = 16.226$ Sig. 0.000; $R^2 = 0.336$; $n = 34$

For post-reform period:

$$\text{Ln (POV)} = 21.250 - 1.826\ \text{Ln (PCNSDP)}$$

Se	3.850	0.420
t	5.52	-4.33
Sig.	0.000	0.000

$F = 18.857$, Sig. 0.000; $R^2 = 0.371$; $n = 34$

The above regression results are based on the data on Poverty Ratio (PR) and the corresponding real Per Capita Net State Domestic Product (PCNSDP) of 17 major Indian states pooled from the years 1982-83 and 1993-94 for the pre-reform period and from the years 1993-94 and 2004-05 for the post-reform period. Our objectives are to estimate the poverty elasticities of per capita income. Therefore, we regressed the log of poverty ratio on log of per capita income. In such model, the coefficient of log of per capita income directly gives the poverty elasticity of per capita income.

Intercepts and coefficients of the above log-linear model are statistically significant at 1 percent level in pre as well as post-reform period. The poverty elasticity in India is estimated to be 2.093 in the pre-reform period which declined to 1.826 in the post-reform period. Hence, in spite of impressive economic growth the achievement on poverty front is not so impressive during the post-reform period.

Table: 3.9
Poverty Elasticity of Per Capita Net State Domestic Product (at factor cost) and Net State Domestic Product (at factor cost) during Pre-reform (1982-83 to 1993-94) and Post-reform (1993-94 to 2004-05) Period

States	$E_{PR, PCNSDP}$ Pre-reform	$E_{PR, PCNSDP}$ Post-reform	$E_{PR, NSDP}$ Pre-reform	$E_{PR, NSDP}$ Post-reform
Andhra Pradesh	-0.543	-0.433	-0.322	-0.323
Assam	0.095	-2.942	0.028	-1.254
Bihar	-1.299	-1.018	-0.456	-0.144
Goa	-0.302	-0.151	-0.213	-0.091
Gujarat	-0.561	-0.423	-0.515	-0.270
Haryana	0.424	-0.844	0.219	-0.462
Himachal Pradesh	1.934	-0.911	1.188	-0.610
Karnataka	-0.256	-0.322	-0.183	-0.231
Kerala	-0.891	-0.613	-0.522	-0.484
Madhya Pradesh	-0.553	-0.395	-0.265	-0.089
Maharashtra	-0.221	-0.358	-0.148	-0.211
Orissa	-0.867	-0.096	-0.803	-0.063
Punjab	-0.707	-0.899	-0.401	-0.483
Rajasthan	-0.522	-0.326	-0.433	-0.181
Tamil Nadu	-0.483	-0.635	-0.390	-0.480
Uttar Pradesh	-0.630	-0.931	-0.279	-0.289
West Bengal	-0.859	-0.377	-0.597	-0.271

Note: $E_{PR, PCNSDP}$, and $E_{PR,NSDP}$ denote elasticities of poverty ratio with respect to per capita net state domestic product and net state domestic product respectively.

We also calculated the elasticities of poverty in each of the 17 states with respect to PCNSDP at factor cost and NSDP at factor cost in the pre and post reform periods. They have been presented in the Table: 3.9. The negative signs of the elasticities indicate that poverty ratio moves in the opposite direction of PCNSDP and NSDP. Nine out of the seventeen states experienced improvement in

their poverty elasticities in the post reform period. It is remarkable that out of the remaining eight states which witnessed deterioration in their poverty elasticities, four were the so called BIMARU states. Uttar Pradesh is the only BIMARU state which registered an improvement in its poverty elasticity in the post-reform period.

3.7. Concluding remarks

Our in-depth study using analytical tools of statistics and econometrics offers certain evidences on growth, inequality and poverty in India. There has been significant upward shift in the growth rates of net national product and per capita net national product in India as a consequence of major economic policy shift in 1991 popularly known as the economic reform. Although net national product and per capita net state domestic product both experienced spectacular rise in real terms in the post-reform period, the impressive growth in per capita income cannot be solely attributed to the economic reform of 1991.The improvements in standard of living of people in India as reflected in real per capita income in the post-reform period was also due to slow down in the population growth rate besides the higher economic growth in the post-reform period.

It is quite worrying that while there has been overall impressive achievement on growth fronts in India in the post-reform period, there has been growth disparity across the agriculture and non-agriculture sectors. The poor in India is still mostly concentrated in rural areas and they are mainly dependent on agriculture and allied sectors. Each of agriculture & allied and agriculture sector witnessed a fall and the industrial sector a slight rise in growth rate in the post-reform period. Only service sector registered a marked rise in its growth rate in the post-reform period. Service

sector was the only sector which witnessed structural change in its growth rate in the post-reform period.

The change in the sectoral pattern of growth in the post-reform period has been neither in favour of the poor states nor in favour of the poor people in India. The impressive increase in growth rate in non-agriculture sector particularly in service sector and considerable slow down in the agricultural sector growth rate in the post-reform period resulted in economic disparities between the rich and the poor states of India in the post-reform period. This could be due to the fact that most of the states which are heavily populated also house most of the poor people who are mainly dependent on agriculture for their income and employment. The increasing economic disparities itself partly explain that the benefits of higher economic growth was largely appropriated by the rich states and the rich people

The poverty elasticity in India is estimated to be 2.093 in the pre-reform period which declined to 1.826 in the post-reform period. Out of the major eight states of India which witnessed deterioration in their poverty elasticities (arc elasticity of poverty), four were the so called BIMARU states. Uttar Pradesh is the only BIMARU state which registered an improvement in its poverty elasticity in the post-reform period.

Thus, India has partially failed in translating the higher growth achieved in the post-reform period into poverty reduction effectively. Hence, in spite of impressive economic growth the achievement on poverty front has not been so impressive during the post-reform period.

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CHAPTER-IV

POPULATION GROWTH, POVERTY AND EDUCATION: EVIDENCE FROM INDIA

4.1. Introduction

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Population explosion is primarily responsible for the stress on the global environment (Ehrlich and Ehrlich, 1990), and although other factors are not unimportant population growth is rapidly approaching a level above the earth's long-term capacity to sustain it. The growth of humanity during the twentieth century has brought about major changes to environment (Whitmore, et al., 1991). Population is considered to be an underlying cause to convert forest and woodland areas to pasture and cropland, the harvesting of logs and the gathering of fuel wood (the three sources of deforestation). Population growth also increases the demand for wood, both for timber and for fuel wood. Population growth increases the need for arable land which, in turn, encourages the transformation of forest land to other uses. It also creates pressure on the assimilative capacity of the environment and cause air, water and solid-waste pollution (Cropper and Griffiths, 1994). Hence, population control can be used as a means to reduce environmental degradation. The significance of population, not only number but also its poor demographic features as a whole, is great as it impedes both development and environmental quality.

Population and poverty are closely interlinked and they in fact reinforce each other making it difficult for the poor to come out of poverty and/or contribute to population control. Poverty is considered to be both cause and effect of environmental degradation. The circular link between poverty and environment is an extremely complex phenomenon. Poverty and inequality foster unsustainability because the poor, who rely on natural resources more than rich, deplete them faster as they have no real prospects of gaining access to other types of resources. Moreover, degraded environment can accelerate the process of impoverishment again because the poor depend directly on natural resources.

The growing population and poverty in absolute terms pose serious environmental challenges in India. Over 60 percent of the workforce in India depends on agriculture, fisheries and forests for their livelihoods and the dependence of poor on natural resources is more as compared to the rich (Census of India, 2001). The growth in population in such setting increase pressure on land and other natural resources which lead to unsustainable use of them. There are about 100 million people in the country who live in and around forests and another 275 million for whom forests constitute an important source of livelihoods (Bajaj and Manjul, 2001). Hence, it is important to ensure environmental sustainability to protect the people against poverty in India. The reduction in population growth rate directly reduces stress on the environment. However, between population and environment there are many social, economic, technological and political factors which play vital intervening roles (Commoner, 1990), and these are easier to modify, at least in the short-run than current rates of population growth.

India will become the most populous country in the world with 1.5 billion people by 2040. At present, every sixth person in the world is Indian. India has only 2.4 per cent of the world's total land area. The current population density is at 313 persons per square kilometer. The population of India was 361.08 million in 1951 which rose to 1028.7 million in 2001 (Census, 2001). The average decadal growth rate of population was 21.6 per cent during 1951-61 which only slightly decreased to 21.5 per cent during 1991-01.India supports 17 percent of the world population on just 2.4 percent of world land area. So, from this perspective, we can say that India is over-populated. Not only this, its population has been growing at a considerable high rate over the years. The annual exponential growth rate of population was 0.56 percent during 1901-1911 which reached the peak level of 2.22 percent during 1961-71. The current rate of population growth is 1.85 percent which is higher than those in countries with even much balanced proportion of world population and land area. Given a vast base of India's population and a high growth rate of it, pressure on natural resources is going to increase further.

4.2. Population Growth in India

The exponential population growth rates widely vary across states in India. It varies from the lowest 0.45 percent in Kerala to the highest 2.49 percent in Nagaland during the period 1981-2001. The growth rates are particularly high in North-eastern states, Jammu & Kashmir, Haryana and BIMARU states namely Uttar Pradesh, Bihar, Rajasthan and Madhya Pradesh. The exponential growth rates of population have significantly declined in most of the states in India between 1981-91 and 1991-2001.

The states where population growth rates have actually increased during the same period are Uttar Pradesh, Bihar, Gujarat, Haryana, Nagaland and Sikkim. Among these states, Uttar Pradesh, Bihar and Gujarat are the major states of India in terms of size of population (Table: 4.1).

Table: 4.1
Population Growth in India (1981-2001)

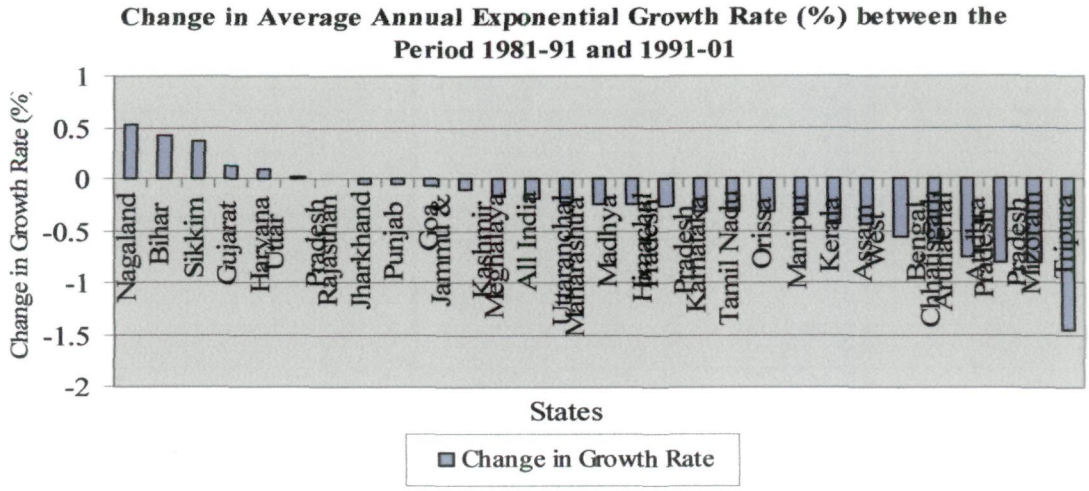
States	Annual exponential growth rate (%)			Change
	1981-91	1991-01	1981-01	(3)-(2)
1	2	3	4	5
Nagaland	4.46	4.98	2.49	0.52
Sikkim	2.51	2.87	1.44	0.36
Meghalaya	2.84	2.67	1.34	-0.17
Jammu & Kashmir	2.69	2.58	1.29	-0.11
Mizoram	3.34	2.53	1.27	-0.81
Bihar	2.10	2.52	1.26	0.42
Rajasthan	2.50	2.50	1.25	0.00
Haryana	2.42	2.50	1.25	0.08
Arunachal Pradesh	3.14	2.39	1.19	-0.75
Uttar Pradesh	2.28	2.30	1.15	0.02
Manipur	2.57	2.22	1.11	-0.35
Madhya Pradesh	2.41	2.17	1.09	-0.24
Jharkhand	2.15	2.10	1.05	-0.05
Maharashtra	2.29	2.05	1.02	-0.24
Gujarat	1.92	2.04	1.02	0.12
Uttaranchal	2.08	1.86	0.93	-0.22
Punjab	1.89	1.83	0.92	-0.06
Assam	2.17	1.73	0.87	-0.44
Chhatisgarh	2.29	1.68	0.84	-0.61
West Bengal	2.21	1.64	0.82	-0.57
Karnataka	1.92	1.61	0.81	-0.31
Himachal Pradesh	1.89	1.62	0.81	-0.27
Orissa	1.83	1.51	0.75	-0.32
Tripura	2.95	1.49	0.74	-1.46
Goa	1.49	1.42	0.71	-0.07
Andhra Pradesh	2.17	1.36	0.68	-0.81
Tamil Nadu	1.43	1.11	0.55	-0.32
Kerala	1.34	0.90	0.45	-0.44
All India	2.14	1.95	0.98	-0.19

Note: The 1981 Census could not be held in Assam. Total population for 1981 has been worked out by Interpolation. The 1991 Census could not be held in Jammu & Kashmir. Total population for 1991 has been worked out by Interpolation.

In the following Figure: 4.1, the positive figures above the state-axis shows increase in growth rate and the negative figures below the state-axis shows decline in the growth rates. Out of twenty eight states of India, six states witnessed increase

in the decadal growth rate of population between 1981-91 and 1991-01. The rest of the states registered decline in population growth rate between the same periods.

Figure: 4.1



4.3. Impact of Population Growth

Rapid population growth plights the lives of a large proportion of the world's people and condemns them to poverty. All the developed countries of today have made the "demographic transition" from the phase of high fertility, high mortality, and high population growth to a phase of low fertility, low mortality and low population growth. Their growth from poverty to prosperity has been facilitated by this transition. Exactly opposite is the scenario in most of the developing countries including India.

High fertility usually implies rapid population growth. Each of birth rate, death rate, natural growth rate and total fertility rate has been showing a declining trend in India since 1981 through 2005 (Table: 4.2). The birth rate has been very high in comparison to death rate during the whole period. But the gap between the

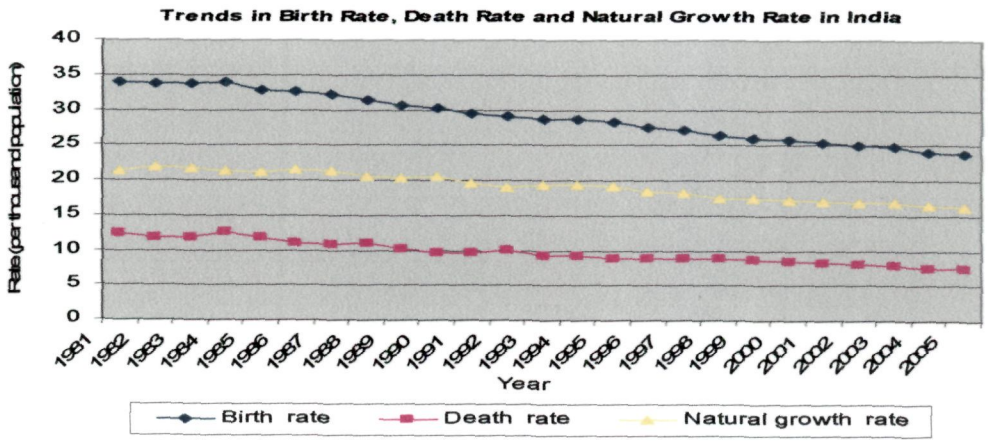
two has been narrowing down, although at a very slow rate, resulting in a very slow rate of decline in the natural growth rate in India.

Table: 4.2
Birth Rate, Death Rate, Natural Growth Rate, and Total Fertility Rate, 1981-2005

Year	Birth rate	Death rate	Natural growth rate	Total fertility rate
1981	33.9	12.5	21.4	4.5
1982	33.8	11.9	21.9	4.5
1983	33.7	11.9	21.8	4.5
1984	33.9	12.6	21.3	4.5
1985	32.9	11.8	21.1	4.3
1986	32.6	11.1	21.5	4.2
1987	32.2	10.9	21.3	4.1
1988	31.5	11.0	20.5	4.0
1989	30.6	10.3	20.3	3.9
1990	30.2	9.7	20.5	3.8
1991	29.5	9.8	19.7	3.6
1992	29.2	10.1	19.1	3.6
1993	28.7	9.3	19.4	3.5
1994	28.7	9.3	19.4	3.5
1995	28.3	9.0	19.3	3.5
1996	27.5	9.0	18.5	3.4
1997	27.2	8.9	18.3	3.3
1998	26.5	9.0	17.5	3.2
1999	26.1	8.7	17.4	3.2
2000	25.8	8.5	17.3	3.2
2001	25.4	8.4	17.0	3.1
2002	25.0	8.1	16.9	3.0
2003	24.8	8.0	16.8	3.0
2004	24.1	7.5	16.6	2.9
2005	23.8	7.6	16.3	2.9

Source: SRS, Registrar General, India.

Figure: 4.2



The graph of birth rate is steeper than that of the death rate indicating that the decline in natural growth rate has been made possible by relatively larger rate of decline in the birth rate (Figure: 4.2).

In order to know the contribution of the reduction of birth rate and death rate to the reduction of natural growth rate during the period 1981 to 2005 in rural, urban and combined sectors, we estimated the following log-linear model:-

$$\text{Ln (CNGR)} = -0.961 + 1.509\ \text{Ln (CBR)} - 0.511\ \text{Ln (CDR)}$$

Se	(0.024)	(0.014)	(0.010)
t	-39.530	107.225	-48.718
Sig.	0.000	0.000	0.000

$n = 25$; $R^2 = 1.000$; $F = 53127$, Sig. 0.000; $d = 1.879$

$$\text{Ln (RNGR)} = -1.011 + 1.552\ \text{Ln (RBR)} - 0.552\ \text{Ln (RDR)}$$

Se	(0.038)	(0.020)	(0.013)
t	-26.799	77.643	-41.191
Sig.	0.000	0.000	0.000

$n = 25$; $R^2 = 0.999$; $F = 21312.303$, Sig. 0.000; $d = 1.695$

$$\text{Ln (UNGR)} = -0.831 + 1.389\ \text{Ln (UBR)} - 0.386\ \text{Ln (UDR)}$$

Se	(0.010)	(0.007)	(0.010)
t	-82.375	185.522	-40.589
Sig.	0.000	0.000	0.000

$n = 25$; $R^2 = 1.000$; $F = 68832.581$, Sig. 0.000; $d = 2.244$

The above results show that all the coefficients of birth and death rates are statistically significant at 1 percent level. In the above model, the coefficients of death rates and birth rates directly give the elasticities of natural growth rate with respect to birth rate and death rate respectively. The elasticities of combined natural

growth rate with respect to birth rate and death rate are 1.509 and –o.511 respectively. These figures for rural and urban areas are 1.552, -0.552 and 1.389, -0.386 respectively. It is obvious from the above figures that the birth rates have greater contribution to the reduction of natural growth rates in each of rural, urban and combined sectors. Dyson (2001) in his study also concluded that India's rate of population growth is falling mainly because the birth rate is falling faster than the death rate.

4.4. Determinants of Population Growth in India

The national family health survey-3 (2005-06) conducted in India identifies education, religion, caste and economic status as factors determining the fertility rate in India. The fertility rates by background characteristics have been presented in the Table: 4.3 below. The rural women have more children than urban women. Education is an important determinant of fertility rate in India. The fertility rate varies from 3.55 children per woman with no education to 1.80 children per woman with education 12 or more years complete. The data also reveal that mere literacy rate matters little in reducing fertility rate among women. The higher education among girls proves more effective and hence it should be vigorously emphasized to reduce fertility rate in India.

Natural growth rate of population is determined together by birth rate and death rate in a country. The birth rate depends on fertility rate prevailing in a society which is, in turn, determined by a number of socio-economic factors. Female education plays a key role in the social development approach to reducing the fertility rate. Female education can be expected to reduce desired family size for

Table: 4.3
Total fertility rate for the three years preceding the survey, percentage of women age 15-49 currently pregnant, and mean number of children ever born to women age 40-49 by background characteristics, India, 2005-06

Background characteristics	Total fertility rate	Percentage of women currently pregnant	Mean number of children ever born to women age 40-49 years
Residence			
Urban	2.06	3.9	3.36
Rural	2.98	5.8	4.33
Education			
No education	3.55	5.9	4.71
<5 years complete	2.45	4.4	3.64
5-7 years complete	2.51	5.2	3.52
8-9 years complete	2.23	4.9	2.97
10-11 years complete	2.08	4.4	2.63
12 or more years complete	1.80	4.1	2.15
Religion			
Hindu	2.65	5.0	3.97
Muslim	3.09	6.7	4.60
Christian	2.35	3.8	3.27
Sikh	1.96	3.6	3.56
Buddhist/Neo-Buddhist	1.96	4.9	3.82
Jain	2.02	6.4	3.27
Other	2.65	4.9	3.87
Caste/tribe			
Scheduled caste	2.92	5.6	4.45
Scheduled tribe	3.12	5.9	4.59
Other backward class	2.75	5.4	4.12
Other	2.35	4.4	3.52
Don't know	1.98	3.5	3.55
Wealth index			
Lowest	3.89	7.2	5.17
Second	3.17	6.2	4.70
Middle	2.58	5.0	4.15
Fourth	2.24	4.6	3.68
Highest	1.78	3.3	2.98
Total	2.68	5.2	4.00

Source: NFHS-3, 2005-06.

a number of reasons, ranging from greater autonomy in defining fertility goals to enhanced receptiveness to modern social norms, reduced dependence on sons for social status and old age security, and the high opportunity cost of time for educated women (Murthy and Dreze, 1995). The negative relationship between female education and desired family size in India is borne out in a wide range of

studies. In addition to reducing desired family size, female education is likely to affect the relationship between desired family size and planned number of births.

One reason for this is that female education reduces infant and child mortality [Jain (1985), Nag (1989), Beenstock and Sturdy (1990), Basu (1992), Murthy, Guio, and Dreze (1995), Govindasamy and Ramesh (1997), Jeffery and Jeffery (1997), Bhargava (1998) and Pandey et al. (1998)]. Educated mothers thus need to plan, fewer births in order to achieve a desired family size. Finally, female education may assist in achieving the planned number of births, especially by facilitating knowledge of, and access to contraception enhancing women's bargaining power within the family.

The role of female autonomy in decision making is increasingly being acknowledged as an important factor impinging on fertility. Dyson and Moore (1983) were the first to discuss this factor in relation to the demographics of the Indian states. The Northern states of India, characterized by low female autonomy due to kinship arrangements that minimize support to married women, display high fertility and high child mortality rates. In the Southern states, women have considerable autonomy: marriages tend to occur within the village to grooms who are not relative strangers, and women maintain considerable contact with their natal families after marriage. The relative bargaining power within couples is highly skewed in favour of males in developing countries like India. Female autonomy is important because it determines the relative bargaining power of women in the household. Female autonomy is one of the variables that potentially mediate the link between female education and fertility, for instance, by giving women greater

control over their fertility [LeVine (1981), Cleland and Wilson (1987), Lindenbaum (1990), and World Bank (1991)].

The relative bargaining powers of males and females have considerable influence over a couple's fertility and resource allocation within the household. Child mortality rates depend, to a significant degree, on the extent of discretionary on children's nutrition and health care. Child mortality rates are observed to be much lower when mothers exercise control over household resources. Hoddinott and Haddad (1995) found that an increase in the wife's share of cash income significantly increases the share of expenditure on food and reduces the shares of alcohol and cigarettes. There is a simple economic reason why mothers devote more resources to the nutrition and health care of children. Since mothers bear a greater proportion of the costs of children, they prefer to have few children and ensure their survival by devoting resources to them. Fathers, on the other hand, prefer to have many children and to devote little by way of resources to each of them. Fathers and mothers, in other words, prefer to be at different points in the quantity-quality trade-off with regard to children. When bargaining power shifts in favour of mother, the couple will have fewer but healthier children (Eswaran, 2002).

4.5. Other Determinants of Fertility

Many of the foregone arguments apply to men as well. Thus improvements in male education may also lower fertility. Nevertheless, the influence of male education on fertility is likely to be smaller than that of female education (unless

fertility decisions are dominated by men), because women bear the primary responsibility for child bearing.

Access to public health services may also play a role in reducing fertility, independently of education and income. Aside from direct effects through improved access to contraception, public health services may reduce fertility by enhancing child survival. These effects may be small where services are of poor quality. The states of north India, for example, lack proper public heath services.

A significant determinant of fertility rate is the desired sex composition of children. The strong preference for male children results in rise in unwanted fertility rate. Economically and culturally, males are deemed to be of greater value than females. Old age security is expected only from male children. Female children, in contrast, are often seen as economic burdens because they have to be married off with dowries that are worth several years' incomes of their parents. Sons are also valued more because, culturally, sons apparently enhance the emotional and spiritual goals of their parents, and they also perpetuate their family name.

The role of urbanization has also been emphasized in the literature (Schultz, 1981, 1994). Urbanization is believed to reduce fertility because children are less likely to contribute to household production and are more difficult to supervise in an urban setting. The decline in fertility rate is likely to proceed at a faster pace in urban areas where people have greater exposure to mass media as well as wider opportunities to observe and discuss the lifestyles of other social groups.

The results of multiple regression model following the stepwise method based on district level data have been presented in the Table: 4.4 and 4.5. The dependent variable is decadal population growth rate during 1991-01 and the explanatory variables entered are sex ratio, overall literacy rate and urban population to account for urbanization in the initial year 1991. The sex ratio has been used as a proxy for sex preference which is not directly observable. Besides these three quantitative explanatory variables, we have also used six dummy variables for each of Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, Orissa, BIMARU states and North-Eastern states as a group. The five states Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan and Orissa constitute the BIMARU states. These states are typically low income, poor states which rank low in human development index and are popularly known as BIMARU states of India.

Table: 4.4
Model Summary

Model	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.217	0.215	9.710
2	0.265	0.262	9.415
3	0.307	0.303	9.149
4	0.315	0.310	9.107
5	0.320	0.314	9.079
6	0.325	0.318	9.055

1. Predictors: (Constant), Sex ratio
2. Predictors: (Constant), Sex ratio, North-Eastern states dummy
3. Predictors: (Constant), Sex ratio, North-Eastern states dummy, BIMARU states dummy
4. Predictors: (Constant), Sex ratio, North-Eastern states dummy, BIMARU states dummy, Overall literacy rate
5. Predictors: (Constant), Sex ratio, North-Eastern states dummy, BIMARU states dummy, Overall literacy rate, Rajasthan dummy
6. Predictors: (Constant), Sex ratio, North-Eastern states dummy, BIMARU states dummy, Overall literacy rate, Rajasthan dummy, Bihar dummy
a. Dependent Variable: Decadal population growth rate.

Model no. 6 is the final filtered model. The result shows that each explanatory variable has expected sign. Since the variance inflation factor (VIF) of none of the explanatory variable exceeds more than 10 collinearity does not pose

any serious problem in the model. 32.5 percent variation in the dependent variable is explained by all the explanatory variables together of the model. The intercept and coefficients of sex ratio, North-eastern states dummy and BIMARU states dummy are statistically significant at 1 percent level. There is negative relationship between sex ratio and population growth.

This means that the preference for male children prevailing in the Indian society, particularly, in the Northern states of India leads to higher population growth in India. Education has a positive impact on population growth. The purpose behind the different dummy variables used in the model was to test the state and regional effect on population growth. The coefficients of overall literacy rate are statistically significant at 10 percent level and each of Rajasthan dummy and Bihar dummy are statistically significant 5 percent. It is thus evident that preference for male children and education are main determinants of population growth in India. There is a direct relation between preference for male children prevailing in the Indian society and population growth. The education has a positive impact on population growth in India. The population growth is significantly higher in the poor and backward states Bihar, Rajasthan, North-eastern states, and BIMARU states as a whole than rest of India.

Thus, there is evidence that the poor and educationally backward states of India are largely responsible for population growth. Hence, poverty contributes to population growth in India and we accept the hypothesis that poverty leads to population growth. The results also lead us to infer that the factor which plays an

important role in determining population growth in one state/region may not be so important in another state/region.

Table: 4:5
Results of Stepwise Regression

Model		Coefficients	t	Sig.	Collinearity statistics	
					Tolerance	VIF
1	(Constant)	103.626	15.917	0.000		
	Sex ratio	-0.087	-12.525	0.000	1	1
2	(Constant)	101.022	15.967	0.000		
	Sex ratio	-0.085	-12.637	0.000	0.998	1.002
	North-Eastern states dummy	7.236	6.098	0.000	0.998	1.002
3	(Constant)	91.291	14.337	0.000		
	Sex ratio	-0.077	-11.546	0.000	0.957	1.045
	North-Eastern states dummy	9.581	7.841	0.000	0.891	1.122
	BIMARU state dummy	4.933	5.869	0.000	0.865	1.156
4	(Constant)	95.543	14.556	0.000		
	Sex ratio	-0.076	-11.328	0.000	0.949	1.053
	North-Eastern states dummy	9.341	7.655	0.000	0.886	1.129
	BIMARU state dummy	4.043	4.445	0.000	0.732	1.367
	Overall literacy rate	-0.083	-2.495	0.013	0.821	1.218
5	(Constant)	95.448	14.586	0.000		
	Sex ratio	-0.075	-11.315	0.000	0.949	1.054
	North-Eastern states dummy	9.337	7.676	0.000	0.886	1.129
	BIMARU state dummy	3.512	3.731	0.000	0.679	1.473
	Overall literacy rate	-0.086	-2.585	0.010	0.820	1.220
	Rajasthan dummy	3.647	2.106	0.036	0.910	1.098
6	(Constant)	94.600	14.465	0.000		
	Sex ratio	-0.076	-11.422	0.000	0.947	1.056
	North-Eastern states dummy	9.392	7.740	0.000	0.885	1.129
	BIMARU states dummy	2.891	2.926	0.004	0.613	1.631
	Overall literacy rate	-0.065	-1.887	0.060	0.749	1.335
	Rajasthan dummy	4.444	2.509	0.012	0.865	1.156
	Bihar dummy	3.027	2.014	0.044	0.731	1.369
Dependent Variable: Decadal population growth rate (%).						

Note: - Rajasthan, Orissa and undivided Bihar, Uttar Pradesh, and Madhya Pradesh comprise the BIMARU states.

Both men and women in all the states of India, except Meghalaya, are interested in having more sons than daughters. Meghalaya is the only state of India where men want more sons than daughters but women want more daughters than sons.

Table: 4.6

Correlation between Total Unwanted Fertility Rate and Indicators of Sex Preference for Women and Men age 15-49, by State, 2005-06

	Women		Men		
State	Percentage who want more sons than daughters	Percentage who want more daughters than sons	Percentage who want more sons than daughters	Percentage who want more daughters than sons	Total unwanted fertility rate
	1	2	3	4	5
Andhra Pradesh	9.3	2.6	12.0	2.0	0.3
Arunachal Pradesh	28.3	5.0	30.3	3.2	0.7
Assam	24.1	2.1	17.9	2.8	0.6
Bihar	39.2	1.2	38.5	1.7	1.6
Chhattisgarh	32.8	3.6	24.8	2.4	0.5
Goa	8.7	4.1	11.4	2.1	0.3
Gujarat	22.7	2.3	20.0	1.6	0.6
Haryana	22.0	1.2	18.4	2.2	0.6
Himachal Pradesh	11.8	2.0	9.2	1.1	0.4
Jammu & Kashmir	23.4	3.1	23.9	2.2	0.8
Jharkhand	28.1	2.3	24.6	3.7	1.2
Karnataka	11.6	4.6	12.7	2.7	0.5
Kerala	11.0	5.7	11.8	3.8	0.1
Madhya Pradesh	30.8	1.8	27.9	1.0	1.0
Maharashtra	14.1	2.9	14.3	2.2	0.4
Manipur	28.5	4.2	34.7	3.3	0.5
Meghalaya	11.9	17.0	21.5	13.5	0.7
Mizoram	29.0	22.7	43.5	14.7	0.2
Nagaland	21.4	9.8	28.4	5.0	1.0
Orissa	24.2	2.4	20.3	1.6	0.6
Punjab	17.7	1.6	13.4	1.5	0.5
Rajasthan	34.3	1.5	24.0	1.8	1.0
Sikkim	15.5	5.9	17.1	4.2	0.8
Tamil Nadu	5.7	3.1	7.9	1.8	0.4
Tripura	17.7	3.4	15.2	2.2	0.6
Uttaranchal	20.7	2.1	13.6	1.3	0.7
Uttar Pradesh	33.5	1.7	27.8	1.2	1.5
West Bengal	16.5	3.5	16.6	2.1	0.6
Correlation coefficient	0.66*	-0.25**	0.47*	-0.19**	.....

Source: NFHS-3, 2005-06.

Note:-Total unwanted fertility rate has been worked out by subtracting total actual fertility rate from total wanted fertility rate. The data on total actual fertility rate and total wanted fertility rate are available in national family health survey-3, 2005-06 (NFHS-3, 2005-06). * indicates that the correlation coefficients are statistically significant at 10 percent level and ** indicates that they are insignificant at the same level.

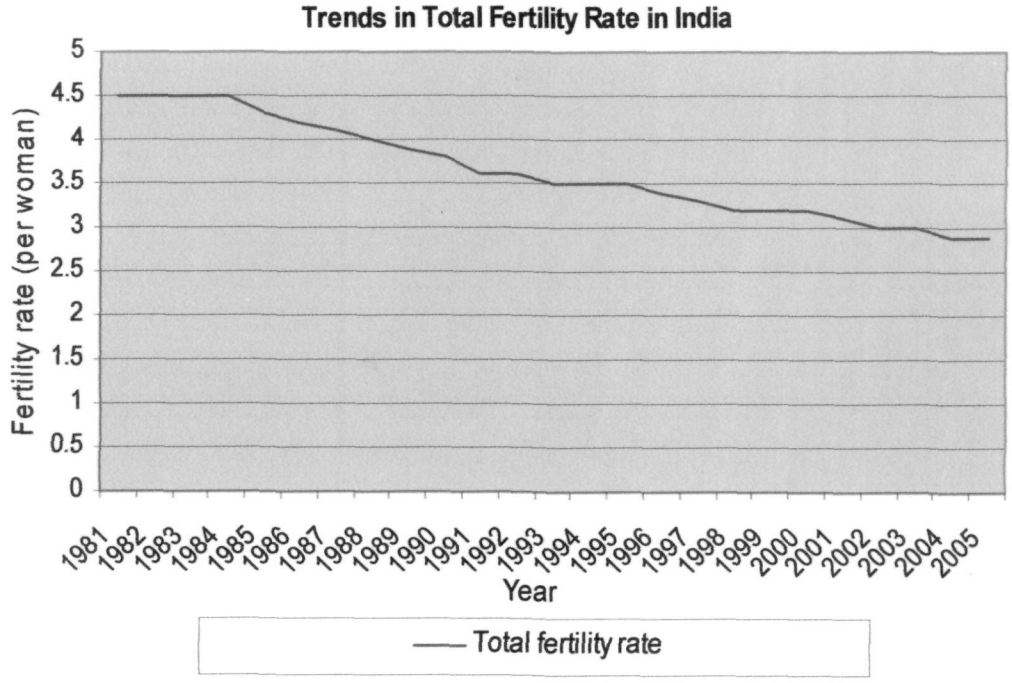
This widespread preference for male children leads to growth in unwanted fertility rate in all the states of India with varying degree. The unwanted fertility rates are particularly high in the four BIMARU states - Uttar Pradesh, Bihar, Rajasthan and Madhya Pradesh. The correlation coefficient between percentage of

women who want more sons than daughters and total unwanted fertility rate is positive and statistically significant at 10 percent level. Similarly, the correlation coefficient between percentage of men who want more sons than daughters and total unwanted fertility rate is also positive and statistically significant at 10 percent level. Unlike it, the correlation coefficients between percentage of men and women who want more daughters than sons and total unwanted fertility rate are negative but statistically insignificant at 10 percent level. (Table: 4.6). Hence, preference for male children in India seems to cause increase in fertility rate.

4.6. Fertility in India and its Relationships with Education

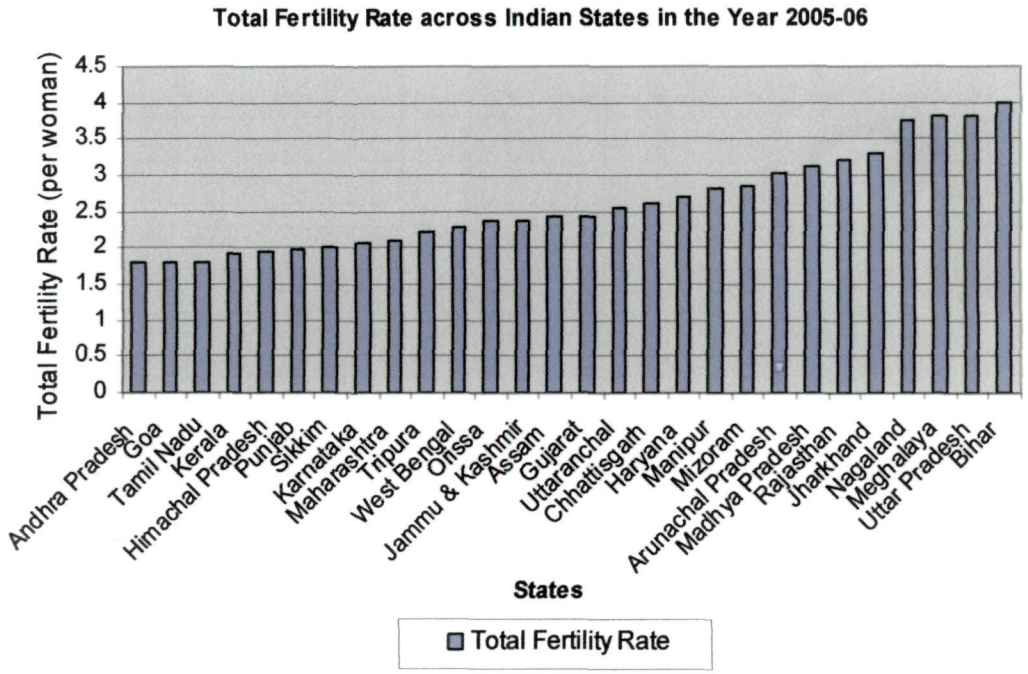
Total fertility rate in India shows a declining trend during the period from 1981 to 2005 (Figure: 4.3). Although total fertility rate at national level has declined substantially from around 4.5 per women in 1981 to less than 3 per women in 2005, it widely varies across states in India.

Figure: 4.3



There are high rates of incidence of total fertility in most of the North-eastern states and BIMARU states of India. Bihar had the highest fertility rate among the twenty eight states of India in 2005-06 followed by Uttar Pradesh (Figure: 4.4). The fertility rates are high in all the BIMARU states except Orissa and in most of the North-eastern states of India. It is remarkable that Uttar Pradesh and Bihar are the largest and second largest states of India respectively in terms of size of population.

Figure: 4.4



The demographer Caldwell (1980) identified universal education as having significantly hastened the demographic transition in the now developed countries. Among other things, the laws for compulsory education raised the cost of children to parents and thus lowered marital fertility.

Other European countries saw fertility transitions synchronous with laws making education compulsory. Weiner (1991, Chap. 6) has observed that even if laws banning child labour exist, they can really be enforced only when education is mandatory. Then the authorities only need peruse the school registers in order to identify potential child labourers

Table: 4.7
Correlation between Total Fertility Rate and Educational Level across Indian States in 2005

States	Total fertility rate	Overall educational level		Female educational level	
		Literate	Secondary & above	Literate	Secondary & above
1	2	3	4	5	6
Andhra Pradesh	1.79	58.55	19.05	50.80	14.20
Arunachal Pradesh	3.03	70.85	20.20	67.00	16.00
Assam	2.42	75.95	20.70	71.15	17.10
Bihar	4.00	56.05	17.15	46.40	10.75
Chhattisgarh	2.62	64.9	19.05	56.05	14.25
Goa	1.79	75.55	32.40	70.90	28.50
Gujarat	2.42	69.00	21.65	60.25	17.20
Haryana	2.69	65.95	25.25	57.10	20.70
Himachal Pradesh	1.94	75.60	30.45	71.10	28.35
Jammu & Kashmir	2.38	65.15	20.95	55.80	16.45
Jharkhand	3.31	61.90	19.90	51.45	14.05
Karnataka	2.07	65.20	22.05	58.05	18.30
Kerala	1.93	84.15	27.30	82.25	27.50
Madhya Pradesh	3.12	60.15	17.10	50.55	13.10
Maharashtra	2.11	71.70	23.20	64.95	18.40
Manipur	2.83	77.30	27.00	71.30	21.95
Meghalaya	3.80	82.35	21.75	80.70	21.80
Mizoram	2.86	90.35	19.65	90.10	16.85
Nagaland	3.74	80.50	27.30	77.00	24.10
Orissa	2.37	63.15	18.10	56.20	14.35
Punjab	1.99	70.20	27.85	65.95	27.05
Rajasthan	3.21	54.50	13.75	43.10	9.00
Sikkim	2.02	78.10	19.05	71.50	17.40
Tamil Nadu	1.80	72.00	22.05	65.05	18.20
Tripura	2.22	77.05	18.60	72.55	14.90
Uttar Pradesh	3.82	68.30	25.10	60.05	22.00
Uttaranchal	2.55	56.40	16.45	47.70	12.55
West Bengal	2.27	70.75	19.05	65.00	14.90
Correlation Coefficient	.....	**-0.14@**	**-0.25#**	**-0.15$**	**-0.27***

Note: - @, #, $ and * are correlation coefficients of column 1 with column 2, 3, 4, and 5 respectively.
* is statistically significant at 10 percent level.

The correlation coefficients of total fertility rate with overall educational level as well as female educational level are negative and expected. These negative correlation coefficients become stronger when the level of education improves from mare literate to secondary & above. The correlation coefficients strengthen from -0.14 to -0.25 in case of overall educational level and from -0.15 to -0.27 in case of female educational level when the level of education changes from mare literate to secondary & above (Table: 4.7). Thus education in general and girl's education in particular has a positive impact on fertility rate. Moreover, the higher the level of education the greater is its positive impact on fertility rate.

4.7. Population Growth, Poverty, and Infant Mortality

Poverty begets poverty. The positive feedback loop between population growth and poverty is one powerful example. High fertility usually leads to rapid population growth. This typically lowers the rate of growth of per capita income and, in addition, has serious consequences for the distribution of income across different classes of people. The rapid population growth is likely to retard growth in per capita income in India partly because people are mostly dependent on agriculture which is fixed in supply. In the face of population growth, the nation's savings rate has to be higher if income per capita is to be maintained. Thus, even if the production inputs other than labour are not fixed but can be accumulated over time, rapid population growth will impede the elimination of poverty. Population growth rates are typically higher, in low-income populations.

High infant mortality causes parents to compensate with large numbers of births. Children provide one of the few available means of old age security.

Knowledge about birth control techniques is sparse and the availability of contraceptives is limited. Women frequently have low levels of education and in some cultures large families are the only possible way for women to achieve status. Large populations in turn tend to increase the degree of poverty by lowering wages and by spreading the family resources allocated to children over a large number.

The income distribution consequences of high fertility follow from the fact that owners' production inputs other than labour typically benefit from population growth. Since the poor in developing countries are typically those without any assets, by skewing the income distribution against the poor, rapid population growth will result in poverty persisting longer than it otherwise would.

It is argued that high fertility is a cause of poverty. However, the causation often goes in the opposite direction as well. Poverty encourages high fertility for reasons having to do with old-age security, and this increases future poverty. Using data on fifty-nine (mostly) developing countries, Eastwood and Lipton (1999) present evidence on the relationship between fertility and poverty and the direction of causation if poverty were more strongly correlated with lagged values of fertility (e.g., ten years earlier) than with current values, one might infer that the causation goes from fertility to poverty; if the reverse is true, then the inference would be that the causation goes from poverty to fertility. Their finding is that while poverty is correlated with both measures, the correlation with lagged fertility measures is much stronger.

Population growth also has adverse effects on the environment: Forests are depleted for fuel, ground water is exhausted, and agricultural land is overused, and

so on. All of these inputs, which can be interpreted as various forms of capital, contribute to the productivity of labour and, therefore, the standard of living of those who constitute the poor. Population growth also puts increased pressure on the natural resource base. Pushing larger numbers of people onto marginal land increases soil erosion and deforestation which are sources of income and livelihood for the poor. Increasing population density can cause the carrying capacity of the land to be exceeded.

There are good, additional reasons for the governments of developing countries to be more proactive with regard to population problems. A statistical relationship that demographers have long focused on is the decline in a country's infant or child mortality rate and the population growth rate. As the country's infant mortality rate declines, the population rate of growth subsequently declines. In fact, there is a causal connection between the two: all else constant, reductions in infant mortality rates are responsible for declines in the rate of population growth.

The reason for this causal connection is that the possibility of the death of infants exposes parents to considerable risk. There are likely few things that parents fear more than the possibility of losing their children. Faced with the possibility of infant mortality, parents with an old-age security motive overcompensate for infant mortality. In other words, parents tend to hoard children to protect themselves from against the contingency of being left without support in old age. The extent of the "excess" fertility will naturally depend on the infant mortality rate.

Table: 4.8
Total Fertility Rate, Poverty Ratio and Infant Mortality Rate across Indian States in 2005

States	Total fertility rate	Poverty ratio	Infant mortality rate
1	2	3	4
Andhra Pradesh	1.79	15.8	57
Arunachal Pradesh	3.03	17.6	37
Assam	2.42	19.7	68
Bihar	4.00	41.4	61
Chhattisgarh	2.62	40.9	63
Goa	1.79	13.8	16
Gujarat	2.42	16.8	54
Haryana	2.69	14.0	60
Himachal Pradesh	1.94	10.0	49
Jammu & Kashmir	2.38	5.4	50
Jharkhand	3.31	40.3	50
Karnataka	2.07	25.0	50
Kerala	1.93	15.0	14
Madhya Pradesh	3.12	38.3	76
Maharashtra	2.11	30.7	36
Manipur	2.83	17.3	13
Meghalaya	3.8	18.5	49
Mizoram	2.86	12.6	20
Nagaland	3.74	19.0	18
Orissa	2.37	46.4	75
Punjab	1.99	8.4	44
Rajasthan	3.21	22.1	68
Sikkim	2.02	20.1	30
Tamil Nadu	1.80	22.5	37
Tripura	2.22	18.9	31
Uttar Pradesh	3.82	32.8	73
Uttaranchal	2.55	39.6	42
West Bengal	2.27	24.7	38
Correlation Coefficient		$0.36^{@}$	$0.27^{\#}$

Note: - @ and # are correlation coefficients of column 1 with column 2 and 3 respectively. Both are statistically significant at 10 percent level.

The Pearsonian correlation coefficients of total fertility rate with poverty ratio and infant mortality rate are positive and statistically significant at 10 percent level indicating that both poverty and infant mortality have a negative impact on fertility rate in India (Table: 4.8).

4.8. Concluding Remarks

India has achieved some success on population front but there is still a lot of scope for the reduction of population growth rate in many Indian states. There are

particularly high rates of population growth in most of the North-eastern and BIMARU states of India. The population in large and poor Indian states namely Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh continues to grow at a very high rate. As a result, land-man ratio has been continuously declining. The preference for male child, poverty and illiteracy are the major factors contributing to higher population growth in India. The prevalence of high infant and child mortality rates in relatively poor states are also contributing to the high growth rate of population. The low chance of the survival of a child leads people to have more children to avoid the risk of being child-less.

The high population growth rate and the stagnant low growth of Indian agriculture in the post reform period has exacerbated the income and employment situation for the poor people dependent on agriculture in rural areas. The service sector has consistently experienced higher growth rate in the post-reform period. This growth of service sector is more conducive to sustainable development as employment elasticity of growth in this sector is relatively high in comparison to other sectors. The service sector is least dependent on natural resources. Hence, natural resources are not subjected to intensive use when its growth picks up. It is human capital-intensive. Therefore, ensuring the supply of efficient human-capital on a continuous basis is key to consistent higher growth of service sector in India. Promotion of education will serve the dual purpose- on one hand it will accelerate the growth of service sector and on the other it will help stabilize the population growth via reducing the fertility rate of women directly. Education, particularly girls' education, has a significant positive impact on fertility rate among women in

the age group 15-49, 19-24 and 20-29. It is here remarkable that fertility rate in India is highest in the age groups 19-24 and 20-29 years. The years of higher education of girls in India coincides with these two age groups. Thus, the promotion of higher education in general and girls' education in particular is key to reducing the population growth, smooth and continuous high rate of growth of the service sector and , hence, for sustainable economic development in India.

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CHAPTER-V
INDIA'S ENVIRONMENTAL STATUS: A REVIEW

5.1. Introduction

The process of economic development has resulted in large scale environmental degradation across the world. The balance between man and natural resources has changed considerably. This is posing a threat to the existence of man itself. The initial narrow concepts of economic development, without giving any weight to the environment, have now been revised by the economists. However, the damage to the environment has been done not only by careless developmental activities but also by lack of social and infrastructural development. India's developmental experience has also been similar to what has been observed in many countries of the world. In the process of economic development, India's environment has been damaged considerably. This has posed threat to food security, created health and natural disasters and large scale economic costs.

5.2. Land

The area under barren and uncultivable land is generally unsuitable for agriculture either because of topography or its inaccessibility. Recently, the area under non-agricultural land has increased due to increase in developmental activities; e.g. housing, transport system, irrigation, etc. About 24 Mha are occupied by the housing, the industry and for other non-agricultural uses, 19.2 Mha are snowbound and remote, leaving only 263 million hectare for agriculture, forestry, pasture and other biomass production. The net sown area increased

from 118.75 Mha in 1950-51 to 140.27 Mha in 1970-71, mostly through reclamation of old fallow and cultivable wastelands and diversion of groves. Since 1970-71, the net area sown has remained almost the same at around 142 Mha levels. Cropping intensity has increased from 111.1in 1950-51 to 135.10 in 2004-05 (Table: 5.1). The increase in cropping intensity shows the increase in intensive use of agricultural land in India. This increasing intensive use of agricultural land to meet the food demand of growing population by using modern technology has led to increase in salinity of scarce land in India. The data shows that land use in the country, over the last five decades, has undergone drastic change. Land under agriculture has almost doubled, tree crops and groves have dwindled to less than one-sixth, and fallow land has considerably declined. Large tracts of fertile agriculture and forest land have been diverted for urbanization and settlements. Deforestation contributes to loss of precious top soil which amounts to about 35 percent of the global sediment load going to oceans even though water flowing through the rivers in India is only about five percent of the flow of rivers in the world.

Productive lands are essential to meet India's need for food, fuel and fodder. In addition, they help conserve biodiversity and water. According to the National Wasteland Development Board in the Ministry of Rural areas and Employment some 175 million hectares (53% of the country's total geographic area) is degraded. This compromises life support systems and livelihood of poor and tribal people adversely as shown in the earlier section.

Table: 5.1
Trends in Land Use Classification in India (In million hectares)

Classification	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2004-05 (P)
I. Geographical Area	328.73	328.73	328.73	328.73	328.73	328.73	328.73
II. Reporting Area for Land Utilisation Statistics (1 to 5)	284.32	298.76	303.76	304.16	304.86	305.08	305.23
1. Forests	40.48	54.05	63.92	67.47	67.81	69.62	69.67
2. Not Available for Cultivation (a+b)	47.52	50.75	44.64	39.62	40.48	41.55	42.30
(a) Non Agricultural Uses	9.36	14.84	16.48	19.66	21.09	23.81	24.72
(b) Barren and Unculturable Land	38.16	35.91	28.16	19.96	19.39	17.74	17.58
3. Other Uncultivated Land excluding fallow land (a+b+c)	49.45	37.64	35.06	32.32	30.22	27.71	27.00
(a)Permanent Pastures and Other Grazing Land	6.68	13.97	13.26	11.97	11.40	10.83	10.43
(b) Land Under Miscellaneous Tree Crops and Groves not Included in Net Area Sown	19.83	4.46	4.30	3.61	3.82	3.32	3.38
(c) Culturable Wasteland	22.94	19.21	17.50	16.74	15.00	13.56	13.19
4. Fallow Land (a+b)	28.13	22.82	19.88	24.75	23.36	25.03	24.94
(a) Fallow Land Other Than Current Fallows	17.45	11.18	8.76	9.92	9.66	10.19	10.72
(b) Current Fallows	10.68	11.64	11.12	14.83	13.70	14.84	14.22
5. Net Area Sown (6-7)	118.75	133.20	140.27	140.00	143.00	141.16	141.32
6. Gross Cropped Area	131.89	152.77	165.79	172.63	185.74	185.70	190.91
7. Area Sown More Than Once	13.15	19.57	25.52	32.63	42.74	44.54	49.59
8. Cropping Intensity*	111.1	114.70	118.20	123.30	129.90	131.60	135.10
III. Net Irrigated Area	20.85	24.66	31.10	38.72	48.02	54.84	58.54
IV. Gross Irrigated Area	22.56	27.98	38.20	49.78	63.20	75.82	79.51

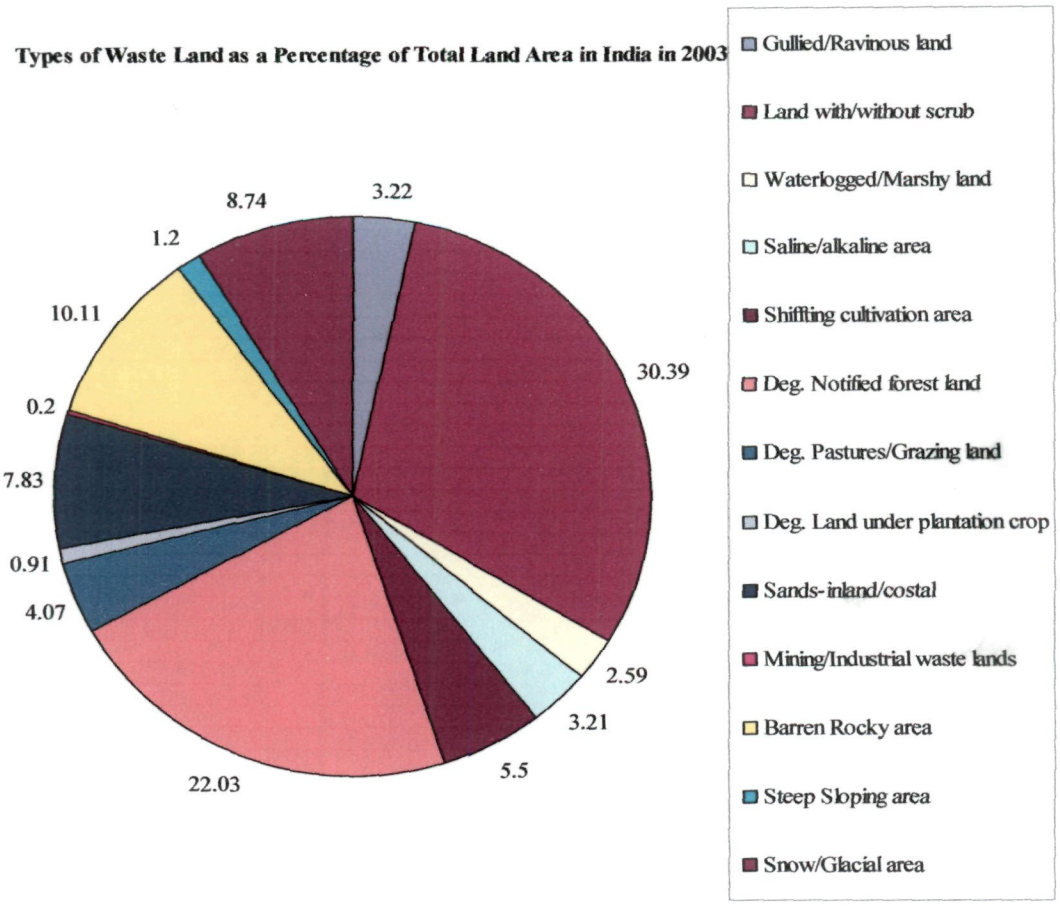
Source: Agricultural Statistics at a Glance 2007, Directorate of Economic & Statistics, Ministry of Agriculture. Where: P: Provisional, *: Cropping Intensity is obtained by dividing the gross cropped area by the net area sown.

5.2.1. Land Degradation in India

India is the seventh largest country in the world, with a total land area of 3,287,263 sq. km. (1,269,219 sq. miles). Ever-growing population and urbanization is creeping into its forests and agricultural lands. Although India occupies only 2.4 per cent of the world's total land area, it supports over 16.7 per cent of the entire global population. Of the total geographical area of 328.73 Mha, 306 Mha comprises the reporting area and 146.82 Mha land is degraded land. In India, an estimated 146.82 Mha area suffers from various forms of land degradation due to water and wind erosion and other complex problems like alkalinity/salinity and soil acidity due to water logging. In India, 22.03 percent area is degraded forest land,

5.5 percent covers shifting cultivation, 4.07 percent is degraded pastures/grazing land and 3.21 areas suffer from salinity/alkalinity (Figure: 5.1).

Figure: 5.1



Source: Forestry Statistics in India, 2003.

As high as 20.17 percent of total land area in India was categorized as waste land in 2003. The waste land varies from 3.73 percent in Kerala to 64.55 percent in Jammu & Kashmir. The percentage of waste land is particularly very high in north eastern states namely, Jammu & Kashmir, Manipur, Himachal Pradesh, Nagaland, Sikkim, Meghalaya, Rajasthan, Assam, Arunachal Pradesh, and Gujarat. The waste land in these states varies from 21.88 percent to 64.55 percent of land area (Table: 5.2).

Table: 5.2
State-wise Waste Land of India, 2003

States	Total Wasteland	Total Geographical Area	% to Total Geographical Area
Kerala	1448.18	38863.00	3.73
Punjab	2228.40	50362.00	4.42
West Bengal	5718.48	88752.00	6.44
Haryana	3733.98	44212.00	8.45
Karnataka	20839.28	191791.00	10.87
Bihar	20997.55	173877.00	12.08
Tamilnadu	1276.03	10486.00	12.17
Uttar Pradesh	38772.80	294411.00	13.17
Orissa	21341.71	155707.00	13.71
Madhya Pradesh	69713.75	443446.00	15.72
Goa	613.27	3702.00	16.57
Maharashtra	53489.08	307690.00	17.38
Tripura	23013.90	130058.00	17.70
Andhra Pradesh	51750.19	275068.00	18.81
Mizoram	4071.68	21081.00	19.31
Arunachal Pradesh	18326.25	83743.00	21.88
Gujarat	43021.28	196024.00	21.95
Assam	20019.17	78438.00	25.52
Rajasthan	105639.11	342239.00	30.87
Meghalaya	9904.38	22429.00	44.16
Sikkim	3569.58	7096.00	50.30
Nagaland	8404.10	16579.00	50.69
Himachal Pradesh	31659.00	55673.00	56.87
Manipur	12948.62	22327.00	58.00
Jammu & Kashmir	65444.24	101387.00	64.55
Total	638518.31	3166414.00	20.17

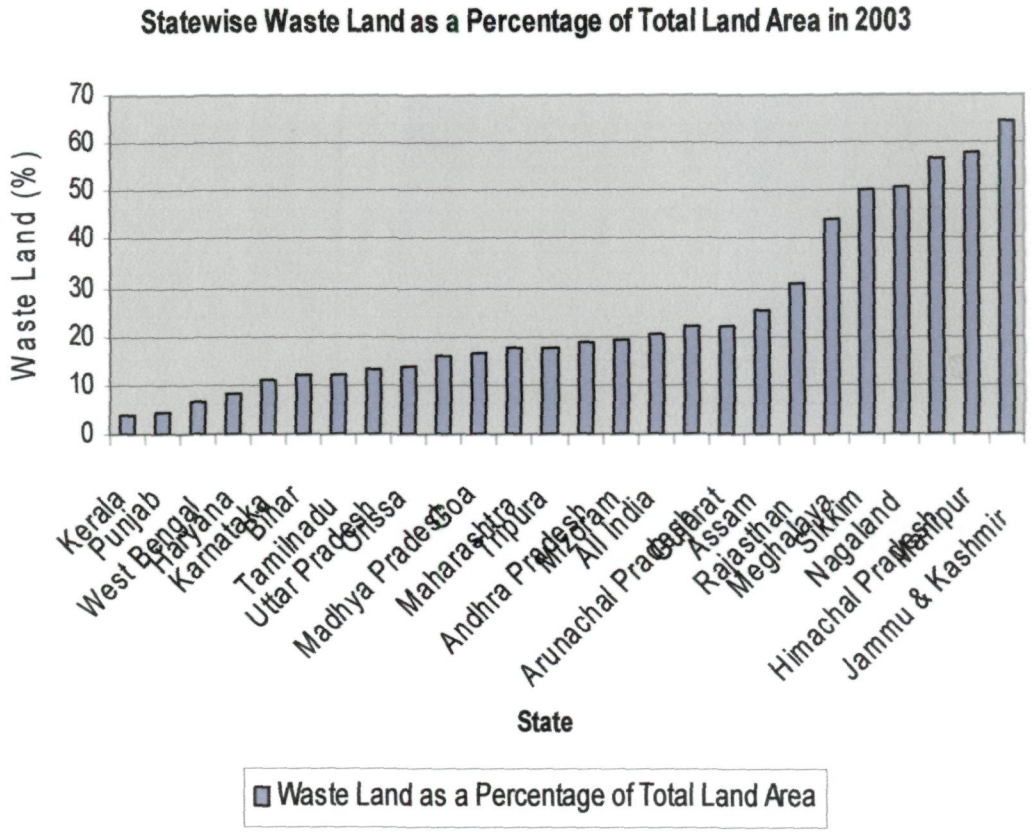
Source: Forestry Statistics in India, 2003.

The extent of land degradation in different states of India can also be seen by having a look at the Figure: 5.2. Arunachal Pradesh, Gujarat, Assam, Rajasthan, Meghalaya, Sikkim, Nagaland, Himachal Pradesh, Manipur, and Jammu & Kashmir have above the all India waste land of 20.17 percent of total geographical area.

The varying degrees and types of degradation stem mainly from unstable use and inappropriate land management practices. Loss of vegetation occurs as a result of deforestation, cutting beyond the silviculturally permissible limits, unsustainable fuel-wood and fodder extraction, shifting cultivation, encroachment into forest

lands, forest fires and over-grazing, all of which subject the land to degradational forces. Other important factors responsible for large-scale degradation are the

Figure: 5.2



extension of cultivation to lands of low potential or high natural hazards, non-adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agro-chemicals such as fertilizers and pesticides, improper planning and management of irrigation systems and extraction of groundwater in excess of the recharge capacity. In addition, there are a few underlying or indirect pressures such as land shortage, short-term or insecure land tenancy, open access resource, economic status and poverty of the agriculture dependent people which are also instrumental, to a significant extent, for the degradation of land.

5.2.2. Factors Responsible for Changes

Agricultural Practices

Out of India's total geographical area (328.7 million hectares) 141.89 million hectares is the net sown area, while 192.80 million hectares is the gross cropped area. The net irrigated area is 60.20 million hectares and the cropping intensity is 135.90 per cent (Table: 5.1).

A change in land use pattern implies variation in the proportion of area under different land uses at a point in two or more time periods. Over the past fifty years, while India's total population increased by about three times, the total area of land under cultivation increased by only 20.2 per cent (from 118.75 Mha. in 1951 to 141.32 Mha. in 2004-05). Most of this expansion has taken place at the expense of forest and grazing land. Despite fast expansion of the area under cultivation, less agricultural land is available on per capita basis.

Direct consequences of agricultural development on the environment arise from intensive farming activities, which contribute to soil erosion, land salination and loss of nutrients. The introduction of Green Revolution in the country has been accompanied by over-exploitation of land and water resources and excessive usage of fertilizers and pesticides. Shifting cultivation (or *Jhum* cultivation) has also been a major factor responsible for land degradation in hilly areas. Leaching due to extensive use of pesticides and fertilizers is a major source of contamination of water bodies.

The extent of agricultural intensification and extensification is characterized by an increase in cropping and irrigation intensity and the imbalanced use of

chemical fertilizers, pesticides and insecticides. It has also led to land degradation, overexploitation of underground water resources and increased use of chemical fertilizers, leading to eutrophication and water pollution in some regions.

Enhanced intensification and extensification also leads to salination, alkalization and water logging in irrigated areas, along with eutrophication of water bodies and ill health of oceans, leading to loss of biodiversity. For achieving and maintaining food security and sustainable forestry, controlling of land/soil erosion is extremely vital.

It is essential to control soil erosion in order to attain and maintain food security, sustainable forestry and agricultural and rural development. Statistics reveal that only 23 per cent of the applied fertilizer is consumed by plants, the remaining 77 per cent is either leached out beyond the root zone or lost by volatilization.

Shifting Cultivation

The current practice of shifting cultivation in the eastern and north-eastern regions of India is an extravagant and unscientific form of land use. According to a recent estimate, an area of 18765.86 sq. km. (0.59 percent of the total geographical area) is under shifting cultivation. The effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of these regions. The earlier 15–20 years cycle of shifting cultivation on a particular land has reduced to two or three years now. This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species. The indigenous biodiversity has been affected to a large extent. As per the statistics, Orissa accounts for the

largest area under shifting cultivation in India.

Excessive Chemical Usage

Soil pollution from heavy metals due to improper disposal of industrial effluents, along with the excessive use of pesticides and mismanagement of domestic and municipal wastes, is becoming a major concern. Though no reliable estimates are available to depict the exact extent and degree of this type of land degradation, it is believed that the problem is extensive and its effects are significant. Some commercial fertilizers also contain appreciable quantities of heavy metals, which have undesirable effects on the environment. The indiscriminate use of agrochemicals, such as fertilizers and pesticides, is often responsible for land degradation. Soil texture, infiltration and permeability characteristics are affected adversely to a considerable extent due to excessive grazing, fire and mismanagement of land under cultivation.

Per hectare consumption of fertilizers has increased from 69.8 kg in 1991-92 to 113.3 kg in 2006-07, at an average rate of 3.3 per cent. There is excessive use of urea and a bias against micronutrients. Against the desirable nitrogenous, phosphatic and potassic (N, P, and K) proportion of 4:2:1 the average use of urea with P and K are in the proportion 6:2 and 4:1 respectively. The Steering Committee of the Planning Commission has observed that "because nitrogenous fertilizers are subsidized more than potassic and phosphatic fertilizers the subsidy tends to benefit the crops and regions which require higher use of nitrogenous fertilizers as compared to crops and regions which require higher application of P and K." The excessive use of urea has also affected the soil profile adversely

(Table: 5.3).

Table: 5.3
Consumption of Nitrogenous, Phosphatic and Potassic Fertilizers (N, P, and K) in India during 2000-01 to 2006-07 (In 1000 tonnes)

Year	N	P	K	Total
2000-01	10920.2	4214.6	1567.5	16702.3
2001-02	11310.2	4382.4	1667.1	17359.7
2002-03	10474.1	4018.8	1601.2	16094.1
2003-04	11077.0	4124.3	1597.9	16799.1
2004-05	11713.9	4623.8	2060.6	18398.3
2005-06	12723.3	5203.7	2413.3	20340.3
2006-07	13772.9	5543.3	2334.8	21651.0

Source: Agriculture Statistics at a Glance, 2006-07, Ministry of Agriculture.

Agricultural Waste Residue Burning

Burning of wheat and rice straw and other agricultural residue has also contributed to loss of soil fertility, apart from causing air pollution. Open field burning of straw after combine harvesting is a common practice in states like Punjab, Haryana and Uttar Pradesh in order to ensure early preparation of fields for the next crop. Punjab alone produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw, annually. This straw is rich in nitrogen, phosphorus and potassium. However, instead of recycling it back into the soil by mulching, it is burnt in the fields. This raises the temperature of the soil in the top three inches to such a high degree that the carbon: nitrogen equilibrium in soil changes rapidly. The carbon as CO_2 is lost to the atmosphere, while nitrogen is converted into a nitrate. This leads to a loss of about 0.824 million tonnes of N, P, and K from the soil. This is about 50 per cent of the total fertilizer consumption in the state. Considering that 90 per cent of rice straw and 30 per cent of the wheat straw is available for recycling, it will be equivalent to recycling of 0.56 million tonnes of nutrients worth Rs. 4 billion (State of Environment Report, India, 2009). Moreover,

agriculture experts also maintain that fire in the fields kills friendly fauna and bacteria.

Soil Erosion

Soil is a unique non-renewable natural resource that supports life on planet Earth. It is estimated that one-sixth of the world's soil has already been degraded by water and wind erosion. In India, approximately130 Mha of land area (or 45 percent of the total geographical area) is affected by serious soil erosion through ravines and gullies, shifting cultivation, cultivated wastelands, sandy areas, deserts and water logging (Govt. of India, 1989).

Soil erosion by rain and river that takes place in hilly areas causes landslides and floods, while cutting trees for firewood, agricultural implements and timber, grazing by a large number of livestock, over and above, the carrying capacity of grass lands, traditional agricultural practices, construction of roads, indiscriminate (limestone) quarrying and other activities, have all led to the opening of hill-faces to heavy soil erosion. Wind erosion causes expansion of deserts, dust storms, whirlwinds and destruction of crops, while moving sand covers the land and makes it sterile. Excessive soil erosion with consequent high rate of sedimentation in the reservoirs and decreased fertility has become serious environmental problems with disastrous economic consequences.

Of the 16 rivers of world, which experience severe erosion and carry heavy sediment load, 3 rivers in India, namely; Ganges, Brahmaputra and Kosi occupy the 2^{nd}, 3^{rd} and 12^{th} position, respectively. The Ganga, Brahmaputra and Kosi rivers carry huge amounts of eroded soil in the form of heavy silt, which

deposits as sediments on the river bed. While soil erosion by rain and river in hilly areas causes landslides and floods, deforestation, overgrazing, traditional agricultural practices, mining and Ravines and gullies account for 4 Mha. of land erosion. The area subjected to shifting cultivation reported 4.9 Mha. of eroded land.

In India, erosion rates range from 5 to 20 tonnes per hectare, sometimes going up to 100 tonnes per hectare. Nearly 93.68 million hectares are affected by water erosion and another 9.48 million hectares are affected by wind erosion annually in India. Thus, erosion leads to impoverished soil on one hand, and silting up of reservoirs and water tanks on the other.

Apart from checking soil erosion, the problem of conserving soil moisture is also of immense importance in the extensive regions of low and uncertain rainfall, forming parts of Punjab, Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka. These tracts are characterized by scanty, ill-distributed and highly erosive rains, undulating topography, high wind velocity and generally shallow soils. The period of heavy downpour from August to October is also the period of severe erosion in these regions. About 76 per cent of Rajasthan's arid region is affected by wind erosion of different intensities, and 13 per cent by water erosion. In fact, 4 per cent of Rajasthan's arid area is affected by water logging and salinity or alkalinity.

In India, very little area is free from the hazard of soil erosion. It is estimated that out of 305.9 million hectares of reported area, 146 million hectares is in dire need of conservation measures.

Soil erosion results in huge loss of nutrients in suspension or solution, which are removed away from one place to another, thus causing depletion or

enrichment of nutrients. Besides the loss of nutrients from the topsoil, there is also degradation through the creation of gullies and ravines, which makes the land unsuitable for agricultural production. Subsidence of the land in some areas and landslides in the hilly tracts are problems affecting highways, habitations and irrigation dams.

The use of pesticides above permissible limits enters the food chain, causing health hazards. A major concern particularly about chlorinated hydrocarbons like DDT is their persistence in soil.

Among fertilizers, the conversion of fertilizer-N to gaseous forms-ammonia (NH_3) and various oxides of Nitrogen lead to atmospheric pollution. Escape of fertilizer-N as ammonia gas is called ammonia volatilization. The presence of ammonia and sulphur dioxide may lead to acid rains which ultimately degrade the soil. Atmospheric ammonia contaminates water bodies, impairs visibility and causes corrosion. Nitrous oxide also contributes to global warming.

5.3. Air Pollution

In India, air pollution is proving to be an issue of concern. India's ongoing population explosion along with rapid urbanization and industrialization has placed significant pressure on its infrastructure and natural resources. While industrial development has contributed significantly to economic growth in India, it has done so at considerable cost to the environment. Air pollution and its resultant impacts can be attributed to emissions from vehicular, industrial and domestic activities. The air quality has been, therefore, an issue of social concern in the backdrop of various developmental activities.

There has been unbalanced industrial growth, unplanned urbanization and deforestation. According to reports, India's urban air quality ranks amongst the world's worst of the three million premature deaths in the world that occur each year due to outdoor and indoor air pollution, the highest numbers are assessed to occur in India. Some cities in India have witnessed decline in air pollution levels due to various measures taken by the Governments. In fact, according to a World Bank study, Delhi, Mumbai, Kolkata, Ahmedabad and Hyderabad have seen about 13,000 less premature deaths from air pollution related diseases.

5.3.1. Pressures Affecting Air Quality

Population Growth

India has witnessed an explosive growth of population (0.3 billion in the year 1951 to 1.04 billion in the year 2001) accompanied by unplanned urbanization over the last five decades. The total population of India is expected to exceed 1.6 billion by the year 2050 (Oldenburg, 2005). The population growth has mainly centered on cities with large scale migration of rural population in search of livelihoods. In addition, high population growth rates especially in the Indo-Gangetic (IG) basin has resulted in unbalanced human concentration. The result is that IG basin is one of the most densely populated regions in the world.

This rapidly expanding population, especially in urban areas, is one of the main reasons for environmental concerns in the country. This problem can be narrowed down to many of the large cities in India. Between 1997 and 2020, the population of India's second largest city (Delhi) is expected to grow 1.9 times. In view of the growing population and growing income of people the demand for

vehicles are rapidly growing and causing environmental pollution especially in urban areas of India.

Industrial emissions

It is a major cause of air pollution. It has been hinting towards an alarming situation. India sustains 16.7 per cent of the world's population on 2.4 per cent of its land area, exerting tremendous pressure on its natural resources. In fact, the growing air pollution menace is deadly for the urban poor in India, 50-60 per cent of who live in slums. Following the trends of urbanization and population growth in Indian cities, people buying more vehicles for personal use have perpetuated an increase in vehicles that contribute to vehicular emissions containing pollutants such as sulfur dioxide, nitrogen oxides, carbon monoxide, lead, ozone, benzene, and hydrocarbons (Goyal, 2005).

Vehicular Emission Load

As a result of urbanization in India, pressure on urban transport is likely to increase substantially in this new millennium. Total vehicle population of India is more than 85 million (about 1 per cent share of the world). The increase in vehicles, as well as the presence of other motorized forms of transportation (taxis, autos, trains, buses, etc.), will contribute to the already existent large amount of vehicular emissions. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at near-ground level.

Following the trend of Delhi's urbanization and the lack of appropriate mass transport system, people buying more vehicles for personal use have perpetuated an increase in vehicles. The amount of registered vehicles in Delhi has increased fifty-

one times over a thirty year period. Unbelievably, as much as 17 per cent of the cars in India run in Delhi alone. It has more cars than the total numbers of cars in the individual states of Maharashtra, Tamil Nadu, Gujarat and West Bengal. The vehicle stock in Delhi is expected to almost quadruple by the year 2020.

However, there are several ways by which government, industry, and the public can significantly contribute to the twin goals of reducing our dependence on motor vehicles and consequently reducing harmful emissions. A vigilant, informed, and active citizenry will help ensure that air pollution concerns are factored into the way we plan our cities, towns, and transportation systems.

Industrial Sector Growth

Growth of India's economy is led by a robust performance of the industrial sector (Table: 5.4 and 5.5). The development of a diversified industrial structure, based on a combination of large and small-scale industries, along with growing population has contributed to the growing incidence of air pollution. Impressive growth in manufacturing (average 7.4 per cent over the past 10 years) is a reflection of growth trends in the fields of electronics and information technology, textiles, pharmaceuticals, basic chemicals etc. These industries, belong to the 'red category' of major polluting processes designated by the Central Pollution Control Board (CPCB), and have significant environmental consequences in terms of air emissions. The economic boom has also led to an increase in investments and activities in the construction, mining, and iron and steel sectors. This in turn, is causing a significant increase in brick making units, sponge iron plants and steel re-rolling mills that involve highly polluting proc Air borne emissions emitted from

various industries are a cause of major concern. These emissions are of two forms, viz. solid particles (SPM) and gaseous emissions (SO_2, NO_2, CO_2, etc.).

Table: 5.4
Annual Growth Rates (Percent) for Industries

Period	Mining	Manufacturing	Electricity	General
weight	10.47	79.36	10.17	100
1995-96	9.7	14.2	8.1	13.0
2000-01	2.8	5.3	4.0	5.0
2001-02	1.2	2.9	3.1	2.7
2002-03	5.8	6.0	3.2	5.7
2003-04	5.2	7.4	5.1	7.0
2004-05	4.4	9.2	5.2	8.4
2005-06	1.0	9.1	5.2	8.2
2006-07	5.4	12.5	7.2	11.6
2007-08 (April-Nov)	4.9 (4.2[b])	9.8 (11.8[b])	7.0 (7.3[b])	9.2 (10.9[b])

(a): based on index of industrial production
Base 1993-94=100; (b) figure for April–Nov, 2006-07.
Source: Economic Survey of India, 2007-2008, Ministry of Finance.

Table: 5.5
Trends in Sectoral Growth Rates
(At Factor Cost, 1999-2000 prices)

Year	Agriculture	Industry	Services	Total
2002-03	-7.20	7.10	7.40	3.80
2003-04	10.00	7.40	8.50	8.50
2004-05	0.00	9.80	9.60	7.50
2005-06 (QE)	6.00	9.60	9.80	9.00
2006-07 (RE)	2.70	10.90	110	9.40
Average: Tenth Plan	2.10	8.90	9.30	7.60

Note: QE – Quick Estimates; RE – Revised Estimates.
Source: Annual Report, 2007-2008, Planning Commission.

The industrial units in India are largely located in the states of Gujarat, Maharashtra, Uttar Pradesh, Bihar, West Bengal and Madhya Pradesh. The highest concentration of sulphur dioxide and oxides of nitrogen is, therefore, often found in cities located in these states. Some other industrial states in Delhi, Punjab, Rajasthan and Andhra Pradesh are also becoming critical.

Power Sector

The power sector is a major consumer of coal, using about 78 per cent of the country's coal production. Coal-fired thermal units account for around 62.2 per cent of total power generation in the country. Coal is a major energy source catering to India's growing energy needs. It meets about 51 per cent of the country's commercial energy needs, and about 70 per cent of the electricity produced in India comes from coal. Thus, coal continues to be the mainstay for the Indian power sector.

India's heavy reliance on coal explains the country's relatively high carbon intensity level. Coal production through opencast mining, its supply to and consumption in power stations, and industrial boilers leads to particulate and gaseous pollution. Radioactive emissions from nuclear power plants are of grave concern as they can cause serious impact both in terms of spatial and inter-generational effects.

In 2006-07, India had encountered 495.54 million tonnes/year of total absolute emissions of CO_2 from the power sector. The annual compound growth rate (ACGR) of CO_2 emissions from power sector has been 4.28 percent in India during 2000-01 to 2006-07. The ACGR has been lowest 2.53 percent in the Western region and highest 9.30 percent in the Eastern region during the same period. The CO_2 emissions in each of the five regions, namely, North, East, South, West, and North-East of India show an increasing trend during 2000-2001 to 2006-2007 (Table: 5.6). However, the contribution of India to the cumulative global CO_2

emissions is only 5 per cent. Thus historically, and at present, India's share in the carbon stock in the atmosphere is relatively very small when compared to its population. With high capital costs associated with replacing existing coal-fired plants and the long time required to introduce advanced coal technologies, many of India's highly polluting coal-fired power plants are expected to remain in operation for the next couple of decades, thereby keeping India's carbon emissions on the rise.

Table: 5.6
Region-wise Total Absolute Emissions of Carbon Dioxide (CO_2) from Power Sector in India (2000-2001 to 2006-2007)

(Million Tonne)

Region	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	ACGR (%)
North	97.87	102.74	106.81	110	112.21	120.1	129.55	4.08
East	58.03	61.43	66.59	75.51	83.96	92.52	93.36	9.30
South	89.02	92.18	105.24	108.12	105.6	101.76	109.25	2.94
West	135.19	141.6	148.56	144.13	157.78	153.93	157.72	2.53
North-East	2.21	2.16	2.29	2.46	2.47	2.53	2.65	3.35
India	382.31	400.11	429.48	440.22	462.02	470.85	495.54	4.28

Source: Compendium of Environment Statistics - India, 2007.

Agricultural Waste Burning

Almost all the leading newspapers of northern India published reports on the incident of a thick cloud of smog that enveloped many parts of Punjab and Haryana on 15 October, 2005. People experienced reduced visibility, besides irritation in the eyes and throat. This smog was attributed to the large scale burning of rice straw by farmers.

Punjab alone produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw annually. More than 80 per cent of paddy straw (18.4 million

tonnes) and almost 50 per cent wheat straw (8.5 million tonnes) produced in the state is being burnt in fields every year.

Apart from affecting the soil fertility, this also causes air pollution due to emission of large amounts of suspended particulate matter, besides gases like CH_4, CO_2, NO_2, SO_2, etc., leading to various health hazards like respiratory, skin and eye diseases. Intensive agriculture is also a contributor to greenhouse gases (GHG) like carbon dioxide, methane and nitrous oxide, causing climate change. At an all India level, emissions from the agriculture sector are reported to be 28 per cent of the aggregate national emissions. These include emissions from enteric fermentation in livestock, manure management, rice cultivation and burning of agricultural crop residues.

The National Remote Sensing Agency (NRSA), Hyderabad (Badrinath et al., 2006) conducted a study to calculate the total emissions produced from straw-burning during the harvesting season in Punjab. The calculated total emissions suggested that wheat crop residue burning contributed to about 113 Gg (Giga gram: 10 billion gram or 10 million kg) of CO_2, 8.6 Gg of NO_x, 1.33 Gg of CH_4, 13 Gg PM_{10} (smoke) and 12 Gg of $PM_{2.5}$ during May 2005. The extent of paddy crop residue burning in Punjab only during October 2005 had been estimated to be in an area of 12,685 sq. km., which is much higher than the wheat crop residue burning that occurs during the month of May each year. Emissions from burning paddy fields were estimated to be 261 Gg of CO_2, 19.8 Gg of NO_x, 3 Gg of CH_4, 30 Gg of PM_{10} and 28.3 Gg of $PM_{2.5}$ during October, 2005.

Domestic Sector-Indoor Air Pollution

Contrary to popular belief, air pollution is not an urban problem alone. While in cities suspended particulate matter, sulphur dioxide and nitrogen oxide levels are much higher than permissible limits, in rural areas indoor pollution kills half a million prematurely every year.

The cost of air pollution in 36 major Indian cities has been very high. For instance, Brandon, et al. (1995) estimates that in 1995 there were 19.8 million hospital admissions and 1200 million minor sicknesses per year. In Delhi alone there are human health damages worth Rs. 1170 million per year.

In rural areas, air pollution is primarily produced indoor from the use of firewood and other unclean sources of cooking fuel. Since 72% of India lives in rural areas this form of air pollution has significant impact on the population as a whole. Indoor pollution causes 0.41 to 0.57 million premature deaths/year and for each death there are about 6 person years of illness (Parikh, Smith and Laxmi, 1999). Making cleaner technologies available and affordable can aid in lowering pollution and improving health.

A considerable amount of air pollution results from burning of fossil fuels. The household sector is the second largest consumer of energy in India after the industrial sector. National Family Health Survey-3 (NFHS-3) found that 71 per cent of India's households use solid fuels for cooking and that 91 per cent of rural households also do the same. According to National Family Health Survey-3, more than 60 per cent of Indian households depend on traditional sources of energy like fuel-wood, dung and crop residue for meeting their cooking and heating needs

(Table: 5.7). The poor in rural areas of India are mainly dependent on these traditional sources of energy for cooking and lighting. This not only causes pollution related diseases like acute respiratory infection, tuberculosis etc. but also consumes a lot of their time for gathering them.

Table: 5.7
Proportion of Households by Type of Fuel Use

Types of Fuel	NFHS-1	NFHS-2	NFHS-3
LPG	11	17	25
Kerosene	8	8	3
Coal	4	3	2
Wood	64	59	49
Dung Cakes	10	7	11
Others	3	6	10
Total	100	100	100

Source: National Family Health Survey-3, 2005-2006

Burning of traditional fuels introduces large quantities of CO_2 in the atmosphere, when the combustion is complete, but if there is an incomplete combustion followed by oxidation, then CO is produced, in addition to hydrocarbons.

After studying the effects of smoke from solid fuel combustion, Mishra concluded that there is growing evidence that exposure to indoor smoke can cause serious respiratory and other adverse health effects, but the quantity and quality of scientific literature vary considerably by type of health outcome. There is compelling evidence linking indoor smoke to acute respiratory infections in children and chronic obstructive pulmonary disease (COPD) or chronic bronchitis in women' (Mishra, 2004). Based on data from NFHS-1 Mishra, et al. (1999) found that the prevalence of active tuberculosis in India could be reduced by 51 percent if everyone were to use cleaner fuels.

NFHS-3 found a higher TB prevalence in households cooking in the house without having a special room for cooking (518/100,000), compared with households that cook in a separate room of the house (294/100,000), but TB prevalence among households cooking indoors is lower than among households cooking outdoors (543) or in other places (1,223). The higher prevalence among households cooking outdoors may be related to outdoor cooking being more likely than indoor cooking to be done with solid fuels. Table: 5.8 also shows prevalence levels according to the type of fire or stove used among households burning solid fuels. Cooking arrangements that utilize a chimney divert harmful particulates in the smoke away from members of the household. NFHS-3 found much lower levels of TB among households utilizing a chimney than among households not utilizing a chimney when burning solid fuels. Among households using solid fuels, the small number of households utilizing a stove with a chimney report that no one in the household has tuberculosis. Households cooking on an open fire or *chullah* but utilizing a chimney exhibit the second lowest prevalence of TB (278/100,000). Households burning solid fuels without using a chimney exhibit higher prevalence (497/100,000), while the minority of households using some other arrangement not specified have the highest prevalence (1,516/100,000).

Levels of crowding are not sufficient to explain differentials in prevalence of TB as those households with the highest TB levels are the households with the lowest number of persons per sleeping room.

Table: 5.8
Prevalence of Tuberculosis by type of Housing and Fuels/Cooking Arrangements
(No. of persons per 100000 suffering from)

Cooking Fuel	Tuberculosis[2]	Medically treated tuberculosis	Number of usual residents
Electricity or Gas[1]	220	217	124028
Kerosene	564	550	13518
Coal/Lignite/Charcoal	472	436	12001
Wood	463	430	257123
Straw/Shrubs/grass	1012	924	28038
Agriculture Crop Residues	703	703	20872
Dung Cakes	440	416	65681
Others	755	755	640
Total	445	418	522027

Note: total include usual residents with missing information on cooking fuels, place for cooking, and type of fire/stove among households using solid fuels who are not shown separately.
1. includes natural gas and biogas.
2. Includes coal, lignite, charcoal, wood, straw/shrubs/grass, agriculture crop waste and dung cakes
Source: NFHS-3, 2005-2006.

5.3.2 Air Quality Trends

CPCB has identified a list of polluted cities in which the prescribed National Ambient Air Quality Standards (NAAQS) are violated. Action plans are being formulated and 88 of them are being implemented to control air pollution in non-attainment cities by respective states.

Ambient Air Quality Trends

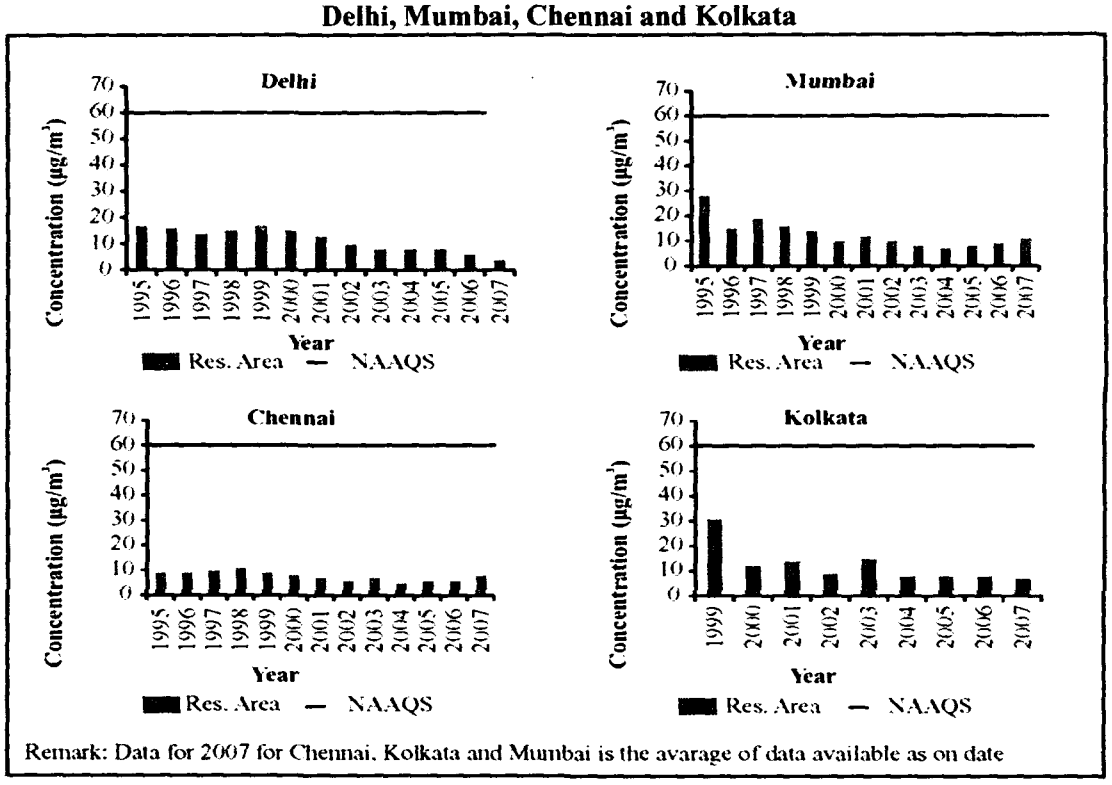
The country-wide ambient air quality monitoring carried out by CPCB at 201 monitoring stations revealed that National Ambient Air Quality Standards (NAAQS) for Respirable Suspended Particulate Matter (RSPM), the main air pollutant of public health concern, were violated at most of the monitoring stations (MoEF, 2005). The estimated annual economic cost of damage to public health from increased air pollution, based on RSPM measurements for 50 cities with the total population of 110 million, reached USD 3 billion (Rs.15,000 crores) in 2004.

Air quality data and trends highlight an emerging phenomenon of conflicting trends for different categories of cities, similar to that experienced by many other countries, thereby reflecting the complex forces behind the impact of growth on environmental action and outcome.

Sulphur Dioxide (SO_2)

Annual average concentration of SO_2 levels are within the prescribed National Ambient Air Quality Standards (NAAQS) at almost all the locations as per the reports of the Central / State last few years.

Figure: 5.3
Trends in Annual Average Concentration of SO_2 in Residential Areas of Delhi, Mumbai, Chennai and Kolkata



Source: Central Pollution Control Board, 2008.

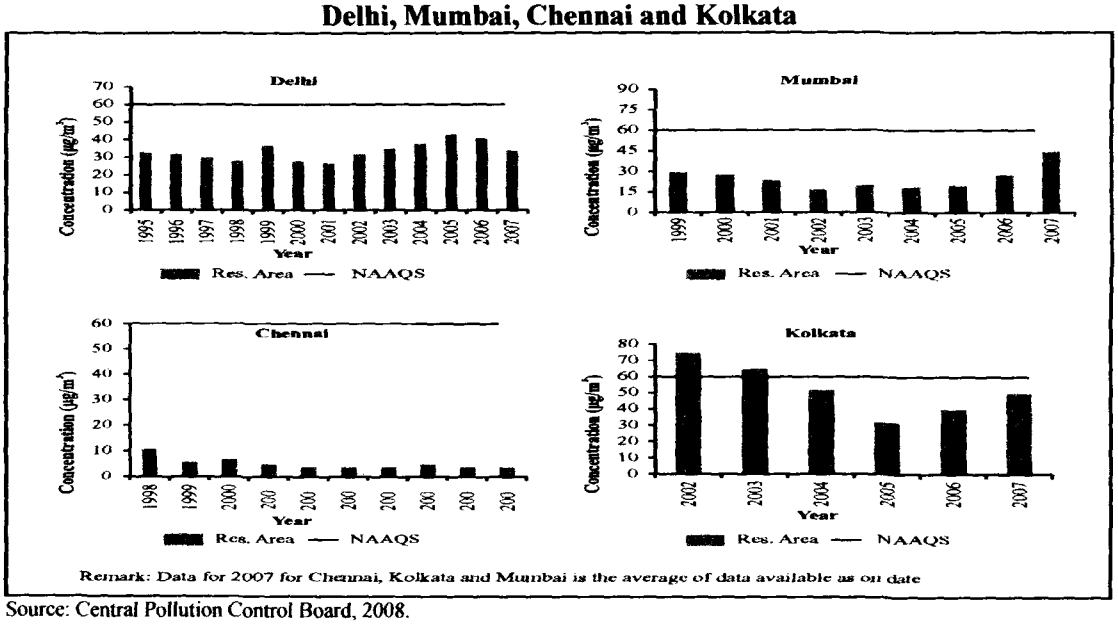
This trend may be due to various measures taken by Pollution Control Board. A decreasing trend has been observed such as reduction of sulphur in diesel etc. and use of LPG instead in SO_2 levels in many cities like Delhi and Mumbai and Kolkata during the last few years. This trend may be due to various measures taken,

such as reduction of sulphur in diesel etc. and use of LPG instead of coal as a domestic fuel (Figure: 5.3).

Nitrogen Dioxide (NO_2)

During the last few years, a decreasing trend has been observed in nitrogen dioxide levels due to various measures taken for vehicular pollution control such as stricter vehicular emission norms. Vehicles are one of the major sources of NO_2 in the country. However, Delhi observed an increasing trend in the past few years, especially after the introduction of CNG. This alternative fuel is known to emit, comparatively, more NO_2 than diesel and petrol (Figure: 5.4).

Figure: 5.4
Trends in Annual Average Concentration of NO_2 in Residential Areas of Delhi, Mumbai, Chennai and Kolkata



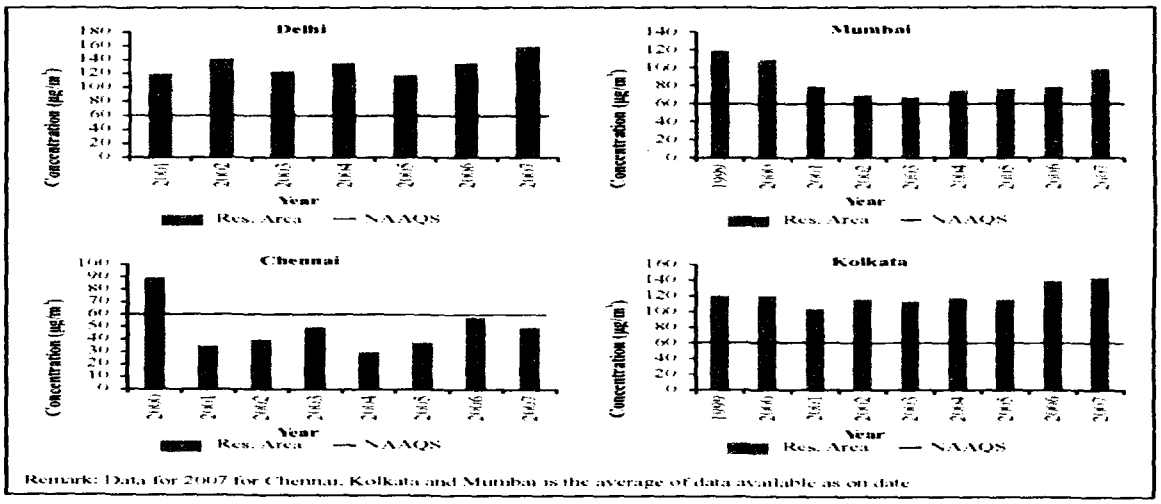
Source: Central Pollution Control Board, 2008.

Particulate Matter

Annual average concentrations of Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter (SPM) exceeded the NAAQS in most of the cities. Delhi, Mumbai, Chennai and Kolkata show increasing trends in RSPM in recent years (Figure: 5.5). In cities like Delhi, this is due to engine gensets, small

scale industries, biomass incineration, boilers and emission from power plants, re-suspension of traffic dust and commercial and domestic use of fuels. A decreasing trend in RSPM however, has been observed in cities like Solapur and Lucknow during the last few years. The probable reason could be corrective measures, like reduction of sulphur in diesel, use of premix 2-T oil dispensor and stringent standard for particulate matter in diesel vehicles. Lower levels of RSPM and SPM are also found to be governed by factors like presence of excellent ventilation effects owing to sea and land breeze, in coastal cities and wet deposition in the month of monsoon.

Figure: 5.5
Trends in Annual Average Concentration of RSPM in Residential Areas of Delhi, Mumbai, Chennai and Kolkata



The highest concentration from residential areas was observed at a monitoring station located at M/s Modi Oil & General Mills, Gobindgarh and in case of industrial areas at Sub-divisional Office, Satna. RSPM level at 51 per cent of the monitoring stations in residential areas and 14 per cent of the monitoring stations in industrial areas, was critical (Table: 5.9).

Table: 5.9
Top Ten Locations with Respect to RSPM during 2007 in Residential Areas

Residential Area		
Location	States	Annual Average Conc. ($\mu g/m^3$)
M/s Modi Oil & General Mills, Gobindgarh	Punjab	252*
PPCB Office Building, Ludhiana	Punjab	231*
Ahirpara, Khurja	Uttar Pradesh	201*
Deputy ka Padao, Kanpur	Uttar Pradesh	198*
Town Hall, Delhi	Delhi	198*
Kidwai Nagar, Kanpur	Uttar Pradesh	197*
A S School, Kanna	Punjab	196*
Aminabad, Lucknow	Uttar Pradesh	193*
Aliganj, Lucknow	Uttar Pradesh	190*
Shadra Nagar, Kanpur	Uttar Pradesh	185*

Source: Central Pollution Control Board, 2008.

Table: 5.10
Top Ten Locations with respect to SPM
During 2007 in Residential Areas

Residential Area		
Location	State	Annual Average Conc.(µg/m 3)
Town Hall, Delhi	Delhi	476*
Regional Office, Noida	Uttar Pradesh	447*
Kidwai Nagar, Kanpur	Uttar Pradesh	442*
Deputy Ka Padao, Kanpur	Uttar Pradesh	440*
Ahirpara, Khurja	Uttar Pradesh	432*
Shivpur/Sigra, Varanasi	Uttar Pradesh	422*
Sharda Nagar, Kanpur	Uttar Pradesh	421*
A-1 Platters, Amritsar	Punjab	411*
Aminabad, Lucknow	Uttar Pradesh	402*
Jail Chauraha, Jhansi	Uttar Pradesh	402*

* - Locations where annual mean concentration of SPM exceeded the NAAQS of 140 µg/m for Residential areas.
Source: Central Pollution Control Board, 2008.

As far as SPM is concerned, highest concentrations were observed at Town Hall, Delhi and Regional Office, Udaipur from the residential and industrial areas, respectively. The percentage violation of NAAQS (24 hourly avg.) was less than two per cent at 68 monitoring stations of industrial and 30 monitoring stations of residential areas. In the remaining stations, it was two per cent or more (Table: 5.10).

There are different types of pollutants affecting the individual differently. The pollutants in air, namely –SO_2, NO_x and Suspended Particulate Matter (SPM) - damage the human respiratory and cardio-respiratory systems in various ways. The elderly, children, smokers and those with chronic respiratory diseases are the most vulnerable. It has been reported that high levels of pollution affect mental and emotional health too. Elevated levels of lead in children result in impaired neurological development, leading to lowered intelligence quotient, poor school performance and behavioural difficulties.

A study conducted by All India Institute of Medical Sciences and Central Pollution Control Board in Delhi showed that exposure to higher levels of particulate matter contributed to respiratory morbidity. It indicated that the most common symptoms relating to air pollution were irritation of eyes (44 per cent), cough (28.8 per cent), pharyngitis (16.8 per cent), dyspnea (16 per cent) and nausea (10 per cent). In Mumbai, the prevalence of both symptoms and signs of such diseases is around 22.2 per cent.

Among the six major communicable diseases, maximum cases (2,58,07,722) were reported for Acute Respiratory Infection while maximum number of people (7,073) died due to Pulmonary Tuberculosis in India, during the year 2006.

Particulate matter less than 2.5 micron ($PM_{2.5}$) is the most harmful particle as it reaches the alveolar region (i.e. blood and gas exchange region) of the respiratory tract, causing various respiratory and cardiovascular ailments. It has also been established that fine particles are more prone to get enriched with toxic and carcinogenic substances than the coarse particles.

The annual average concentration of $PM_{2.5}$ was found to be 102 $\mu g/m^3$ during 2007. The monthly average concentration of $PM_{2.5}$ varied from 34 $\mu g/m^3$ to 198 $\mu g/m^3$, change in climatic conditions being a decisive factor. Presence of lesser volume of troposphere in the winter season, aided easy mixing resulting in higher concentrations. Similarly, lower concentrations were observed in monsoon months as particulate matter is washed out due to wet deposition.

Acid Rain

Acid rain is the direct consequence of air pollution caused by gaseous emissions (carbon monoxide, sulphur dioxide, nitrogen oxides) from industrial sources, burning of fuels (thermal plants, chimneys of brick-kilns or sugar mills.) and vehicular emissions. The most important effects of acid rain are damage to freshwater aquatic life, vegetation and damage to buildings and material.

In India, the main threat of an acid rain disaster springs from our heavy dependence on coal as a major energy source. Even though Indian coal is relatively low in sulphur content, what threatens to cause acid rain in India is the concentrated quantity of consumption, which is expected to reach very high levels in some parts of the country by 2020. As energy requirements in India are growing rapidly in tune with the growing economy, coal dependence in the country is expected to grow threefold over the current level of consumption, making the clouds of acid rain heavier over many highly sensitive areas in the country like the northeast region, parts of Bihar, Orissa, West Bengal and coastal areas in the south. Already, the soils of these areas have a low pH value, which acid rain will aggravate further making them infertile and unsuitable for agriculture.

The prospect of increasing consumption of coal in Asia makes the acid rain threat even more real than ever. Possible options for mitigation are: radical improvements in energy efficiency, a switchover to low sulphur fuels like natural gas, greater use of renewable, major cut-down and removal of sulphur from crude oil distillates like diesel, fuel oil, etc., and finally, the widespread use of state-of-the-art pollution control devices in all polluting sectors of the economy.

5.4. Water

Whereas, some regions are drought affected, others are frequently flooded. With the rapid increase in the population, the demand for irrigation, human and industrial consumption of water has increased considerably, thereby causing depletion of water resources. The assumption that "Fresh water is a gift of God which would continue to be available in perpetuity and in abundance" is under challenge. The main preoccupation of water resources development in the country is the extension and development of irrigation and hydel power generation. Water requirements for industrial and domestic use are met partly from reservoirs constructed and managed by the irrigation department. The agriculture production technologies have put a lot of stress on underground water resources.

The projected annual requirement of water in India will be 813 billion cubic meter (BCM) in 2010 which will rise to 1447 BCM in 2050. The highest demand will come from domestic sector. The demand from domestic sector alone will be 688 BCM in 2010 which will rise to 1072 BCM in 2050 (Table: 5.11). Thus the

rising population growth will be putting tremendous pressure on scarce water resources in India and the rate of waste water generation will be accordingly high.

Table: 5.11
Projected Annual Requirement of Water by Different Uses
(Water Demand in Km^3 or BCM)

Sector	Standing Sub-Committee of MOWR		
	2010	2025	2050
Domestic	688	910	1072
Irrigation	56	73	102
Industry	12	23	63
Energy	5	15	130
Others	52	72	80
Total	813	1093	1447

Source: Central Water Commission.
BCM: Billion Cubic Meter.

5.4.1. Water Pollution

The types and sources of water contamination include "point" sources of pollution which usually refers to wastes being discharged from a pipe, and "non-point (which picks up oils and other Contaminants from various areas), irrigation (which carries fertilizers and pesticides into groundwater), leaks from storage tanks and leakage from disposal sites. The non-point sources are technically the most difficult to regulate in India. Water pollution comes from three main sources: domestic sewage, industrial effluents and run-off from activities such as agriculture. Water pollution from domestic and human wastewater causes many severe water borne diseases. The problem of water pollution due to industries is because of the inadequate measures adopted for effluent treatment than to the intensity of industrial activities. The 13 major water polluting industries have been identified and are closely monitored by the Central Pollution Control Board.

Access to safe drinking water remains an urgent need as about 70.5% of the households in the urban area and 8.7 % in rural areas receive organized

piped water-supply and the rest have to depend on surface or ground water which is untreated. Around 22 percent people in India do not have access to safe drinking water. 27 percent people in rural areas and 10 percent in urban areas do not have access to safe water as per Census 2001. The access to safe drinking water widely varies across states in India. The lowest 23.4 percent in Kerala and highest 97.6 percent people in Punjab have access to safe drinking water in India (Table: 5.12).

Table: 5.12
Access to Safe Drinking Water in Households in India (In %)

States	1981			1991			2001		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Andhra Pradesh	25.9	15.1	63.3	55.1	49.0	73.8	80.1	76.9	90.2
Arunachal Pradesh	43.9	40.2	87.9	70.0	66.9	88.2	77.5	73.7	90.7
Assam	NA	NA	NA	45.9	43.3	64.1	58.8	56.8	70.4
Bihar	37.6	33.8	65.4	58.8	56.5	73.4	86.6	86.1	91.2
Chhattisgarh	--	--	--	--	--	--	70.5	66.2	88.8
Goa	22.5	8.6	52.3	43.4	30.5	61.7	70.1	58.3	82.1
Gujarat	52.4	36.2	86.8	69.8	60.0	87.2	84.1	76.9	95.4
Haryana	55.1	42.9	90.7	74.3	67.1	93.2	86.1	81.1	97.3
Himachal Pradesh	44.5	39.6	89.6	77.3	75.5	91.9	88.6	87.5	97.0
Jammu & Kashmir	40.3	28.0	86.7	NA	NA	NA	65.2	54.9	95.7
Jharkhand	--	--	--	--	--	--	42.6	35.5	68.2
Karnataka	33.9	17.6	74.4	71.7	67.3	81.4	84.6	80.5	92.1
Kerala	12.2	6.3	39.7	18.9	12.2	38.7	23.4	16.9	42.8
Madhya Pradesh	20.2	8.1	66.7	53.4	45.6	79.4	68.4	61.5	88.6
Maharashtra	42.3	18.3	85.6	68.5	54.0	90.5	79.8	68.4	95.4
Manipur	19.5	12.9	38.7	38.7	33.7	52.1	37.0	29.3	59.4
Meghalaya	25.1	14.3	74.4	36.2	26.8	75.4	39.0	29.5	73.5
Mizoram	4.9	3.6	8.8	16.2	12.9	19.9	36.0	23.8	47.8
Nagaland	45.6	43.4	57.2	53.4	55.6	45.5	46.5	47.5	42.3
Orissa	14.6	9.5	51.3	39.1	35.3	62.8	64.2	62.9	72.3
Punjab	84.6	81.8	91.1	92.7	92.1	94.2	97.6	96.9	98.9
Rajasthan	27.1	13.0	78.7	59.0	50.6	86.5	68.2	60.4	93.5
Sikkim	30.3	21.7	71.9	73.1	70.8	92.8	70.7	67.0	97.1
Tamil Nadu	43.1	31.0	69.4	67.4	64.3	74.2	85.6	85.3	85.9
Tripura	27.3	22.2	67.9	37.2	30.6	71.1	52.5	45.0	85.8
Uttar Pradesh	33.8	25.3	73.2	62.2	56.6	85.8	87.8	85.5	97.2
Uttranchal	--	--	--	--	--	--	86.7	83.0	97.8
West Bengal	69.7	65.8	79.8	82.0	80.3	86.2	88.5	87.0	92.3
All India	38.2	26.5	75.1	62.3	55.5	81.4	77.9	73.2	90.0

Source: Economic Survey of India-2002.

The most common contamination in the water is from the disease bearing human wastes, which is usually detected by measuring fecal coli form levels. Inadequate access to safe drinking water and sanitation facilities leads to higher infant mortality and intestinal diseases. An uncontrolled disposal of urban waste into water bodies, open dumps and poorly designed landfills, causes contamination of surface water and ground water. For industries, surface water is the main source for drawing water and discharging effluents. Industrial wastes containing heavy metals such as mercury, chromium, lead and arsenic can threaten or destroy marine life.

Water pollution is a major cause of concern in India because in addition to causing ecosystem damage it adversely affects health and thereby impairs economic productivity of people. The current condition of water resources requires that urgent action be taken. For instance, 90% of India's surface water resources are polluted to the extent that they are not fit for bathing (a marked decline in 50 years). Also, about 200 million people do not have access to safe drinking water and utilizable water per capita is decreasing. This level of pollution is set to create conflict over water and scarcity even in regions with abundant water (TERI Vision, 2001).

The socio-economic costs of water pollution are extremely high: 1.5 million children under 5 yrs age die each year due to water related diseases, 200 million person days of work are lost each year and the country loses about Rs.36, 000 crore each year due to water related diseases. Given this, we must aim at water security

for present and future generations, make water available to all and preserve its quality.

The three major contributors towards water pollution are the domestic sector, the industrial sector and the agricultural sector. 75% of the effluents by volume are from the domestic sector. This is because only 20% and 2% of wastewater in Class I and Class II cities respectively is treated. Meanwhile, only 3.15% of rural population has access to sanitation services and 115 million homes have no access to toilets of any type. In the industrial sector only 59% of large and medium industries had adequate effluent treatment in 1995. In the agricultural sector, fertilizer use increased from 7.7 MT in 1984 to 13.4 MT in 1996 and pesticide use increased from 24 TT in 1971 to 85 TT in 1995. (Bhalla, et. al. 1999)

One of the reasons why environmental standards are ignored is because they are seen to be expensive. However, when one calculates the cost of lowering pollution one must compare it to the health and economic benefit from abating pollution. For example, Rs.460 billion is needed to construct toilets in 115 million homes, wastewater treatment in 3696 cities/towns would cost Rs. 180-600 billion depending on technology, and pollution abatement in industries would cost Rs.140billion (about 1.2% of total annual turnover). However, the loss from human health damages due to sanitation and water pollution is 360 billion rupees per year (Parikh et. al, 1998).

5.4.2. Ground Water Depletion

It has been observed that nations across the world often disregard the environment to achieve their present developmental goals. This adversely affects

the future productivity of natural resources and has serious implications for future economic development. India has also learned the similar experiences and it has been felt that the success of the Green-revolution also involved some failures on the environment front. Out of the 5723 assessment units assessed jointly by State Ground Water Departments and Central Ground Water Board (CGWB) in India, 4078 were found safe (71 %), 550 semi-critical (10 %), 226 critical (4 %) and 839 over-exploited (15 %). Just six states [Gujrat, Haryana, Maharashtra, Punjab, Rajasthan and Tamil Nadu comprising 1413 assessment units , have 762 assessment units which are semi-critical, critical or over-exploited (54 % against national average of 29 %)]. Even though the 2004 estimates are not strictly comparable with 1995 estimates, they show deterioration as the differences between the two estimates are too large to be explained by the minor differences in the classification methodology used in the two estimates. The percentage of over-exploited blocks has increased from 4 % in 1995 to 15 % in 2004 which is a matter of concern (Table: 5.13 and Table: 5.14).

Table: 5.13
Ground Water Status of Assessment Units in India
Ground Water Status, 1995

Assessment Units	Total No. of Assessment Units	Dark		Over-exploited	
		No.	% age	No.	% age
No. of blocks	4272	107	3	231	5
No. of mandals (A.P)	1104	24	2	6	1
No. of talukas (Gujarat)	184	14	8	12	7
No. of watersheds (Maharashtra)	1503	34	2	-	-
Total	7063	179	3	249	4

Source: Report of the Expert Group, (2007), Planning Commission.

In most parts of the over-exploited areas, the prime cause of over-exploitation is the rising demand for ground water from agriculture. Further, in many ground water irrigated areas, decisions of cropping pattern and cropping intensity, which are the predominant determinants of agricultural demand for ground water, are being taken largely independent of the ease of ground water.

Table: 5.14
Ground Water Status, 2004

Assessment Units	Total No. of Assessment Units	Semi-critical		Critical		Over-exploited	
		No.	% age	No.	% age	No.	% age
Blocks/mandals/talukas	5723	550	10	226	4	839	15

Source: Report of the Expert Group, (2007), Planning Commission.

Thus, water intensive crops have tended to be grown even in the face of scarcity of ground water, if these crops are perceived to be relatively remunerative. Such distortions occur partly due to the legal/regulatory regime governing ground water and partly to the minimum support price policy, subsidized power used in agriculture and agricultural trade policy currently being followed.

Out of total assessed units of 5705, 546 units were found to be semi-critical, 226 units critical, 837 units over-exploited and 29 units saline in 2004. The percentages of over-exploited units are specially high in Punjab, Rajasthan, Haryana, Karnataka and Tamil Nadu (Table: 5.15).

Over-exploitation leads to increase in pumping depths, reduction in well/tube well yields and rise in costs of pumping ground water. It also leads to widespread and acute scarcity of ground water in summer for irrigation and drinking uses (Report of the Expert Group, 2007). This negative externality from

over-exploitation of ground water by large farmers adversely affects the small and marginal farmers.

Table: 5.15
Categorization of the Status of Ground Water of Blocks/ Mandals/ Talukas in India in 2004

States	Total no. of assessed units	Safe		Semi-critical		Critical		Over-exploited		Rest saline
		No.	%	No.	%	No.	%	No.	%	No.
Andhra Pradesh	1231	760	62	175	14	77	6	219	18	0
Arunachal Pradesh	13	13	100	0	0	0	0	0	0	0
Assam	23	23	100	0	0	0	0	0	0	0
Bihar	515	515	100	0	0	0	0	0	0	0
Chattisgarh	146	138	95	8	5	0	0	0	0	0
Goa	11	11	100	0	0	0	0	0	0	0
Guiarat	223	97	43	69	31	12	5	31	14	14
Haryana	113	42	37	5	4	11	10	55	49	0
Himachal Pradesh	5	5	100	0	0	0	0	0	0	0
Jammu & Kashmir	8	8	100	0	0	0	0	0	0	0
Jharkhand	208	208	100	0	0	0	0	0	0	0
Karnataka	175	93	53	14	8	3	2	65	37	0
Kerala	151	101	67	30	20	15	10	5	3	0
Madhva Pradesh	312	264	85	19	6	5	2	24	8	0
Maharashtra	318	287	90	23	7	1	0	7	2	0
Manipur	7	7	100	0	0	0	0	0	0	0
Meghalaya	7	7	100	0	0	0	0	0	0	0
Mizoram	22	22	100	0	0	0	0	0	0	0
Nagaland	7	7	100	0	0	0	0	0	0	0
Orissa	314	308	98	0	0	0	0	0	0	6
Punjab	137	25	18	4	3	5	4	103	75	0
Rajasthan.	237	32	14	14	6	50	21	140	59	1
Sikkim	1	1	100	0	0	0	0	0	0	0
Tamil Nadu	385	145	38	57	15	33	9	142	37	8
Tripura	38	38	100	0	0	0	0	0	0	0
Uttar Pradesh	803	665	83	88	11	13	2	37	5	0
Uttaranchal	17	12	71	3	18	0	0	2	12	0
West Bengal	269	231	86	37	14	1	0	0	0	0
Total	5705	4067	71	546	10	226	4	837	15	29

Note: Blocks- Bihar, Chhattisgarh. Haryana, Jharkhand. Kerala, Madhya Pradesh. Manipur, Mizoram, Orissa, Punjab, Rajasthan,Tamilnadu. Tripura, Uttar Pradesh, Uttaranchal, West Bengal Mandals (command/ non-command) - Andhra Pradesh
Talukas - Goa, Gujarat, Karnataka, Maharashtra Districts - Arunachal Pradesh. Assam, Delhi, Meghalaya, Nagaland, Districts (Valley) - Himachal Pradesh. Jammu & Kashmir" ** State - Sikkim
Source: Dynamic ground water resources of India (As on March, 2004), Central Ground Water Board, 2006.

5.5. Forests

Forests are not just trees, but part of an ecosystem that underpins life, economies and societies. Forests provide a wide range of services which include prevention of soil erosion, floods, landslides, maintenance of soil fertility, and

fixing carbon from the atmosphere as biomass and soil-organic carbon. The total forest cover of the country, as per the 2005 assessment, is 677,088 sq. km. which constitutes 20.60 per cent of the geographic area of the country.

The following table shows the composition of forests cover in India. The total geographical area of India is 3287263 sq. km. Forests cover is 20.6 per cent of India's total geographic area. 1.66 percent of total geographical area is very dense forest, 10.12 percent is moderately dense forest and rest 8.82 percent is open forest. Non-forest constitutes 78.23 percent of total geographical area of India (Table: 5.16).

Area under grasslands is about 3.9 per cent and deserts cover about 2 per cent. It is estimated that India has about 4.1 million hectares of wetlands (excluding paddy fields and mangroves). Between 1990 and 2000, India gained an average of 3, 61,500 hectares of forest per year.

Table: 5.16
Status of Forest Cover in India, 2005

Class	Area (Sq. Km)	Percentage of Geographical Area
A. Forest Cover		
1. Very Dense Forest	54569	1.66
2. Moderately Dense Forest	332647	10.12
3. Open Forest	289872	8.82
Total Forest Cover	677088	20.6
B. Non-Forest Cover		
4. Scrub	38475	1.17
5. Non-Forest	2571700	78.23
Total Geographical Area	3287263	100

Source: Compendium of Environment Statistics, India, 2007.

This amounts to an average annual reforestation rate of 0.57 per cent. Between 2000 and 2005, this rate has decreased by 92.3 per cent to 0.04 per cent per annum. In total, between 1990 and 2005, India gained 5.9 per cent in forest

cover, or around 3.762 Mha. Measuring the total rate of habitat conversion (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 interval, India gained one per cent in forest and woodland habitat.

5.5.1. Change in Forest Cover

India gained 16605 sq. km. during 1999-2001, 23918 sq. km. during 2001-03 but lost 728 sq. km. during 2003-05. It overall gained 39795 sq. kms forest cover during 1999 to 2005. Arunachal Pradesh, Chhattisgarh, Manipur, and Nagaland were the four states of India which lost forests cover during 1999 to 2005. Between 2003 and 2005, the total forest cover had decreased slightly by 728 sq. km. The states, which have shown a decline in the forest covers, are Nagaland (296 sq. km), Manipur (173 sq. km), Madhya Pradesh (132 sq. km) and Chhattisgarh (129 sq. km). The states of Tamil Nadu (41 sq. km) and Tripura (32 sq. km) have shown a marginal increase in the forest cover, with Arunachal Pradesh (85 sq. km) showing significant increase in the total forest cover (Table: 5.17).

Although the forests cover as a percent of total geographical area in India increased from 20.55 percent in 2001 to 23.41 percent in 2005, a number of states witnessed decline in the forests cover during the same period. Nagaland, Meghalaya, Goa, Arunachal Pradesh, Kerala, Tripura, Mizoram, Assam, Jammu & Kashmir and Haryana are the States where forests cover declined in decreasing order during 2001 to 2005 (Table: 5.18 & Figure: 5.6).

Table: 5.17
Comparative Situation of Forest Cover (Sq. Km.) in India

States	2005	2003	2001	1999	Change (4)-(5)	Change (3)-(4)	Change (2)-(3)	Change (2)-(5)
1	2	3	4	5	6	7	9	10
Andhra Pradesh	44372	44412	43195	44229	-1034	1217	-40	143
Arunachal Pradesh	67777	67692	69760	68847	913	-2068	85	-1070
Assam	27645	27735	25290	23688	1602	2445	-90	3957
Bihar	5579	5573	5375	4830	545	198	6	749
Chhatisgarh	55863	55992	57730	56693	1037	-1738	-129	-830
Goa	2164	2164	1565	1251	314	599	0	913
Gujarat	14715	14814	12913	12965	-52	1901	-99	1750
Haryana	1587	1576	1135	964	171	441	11	623
Himachal Pradesh	14369	14359	12907	13082	-175	1452	10	1287
Jammu & Kashmir	21273	21273	19886	20441	-555	1387	0	832
Jharkhand	22591	22569	22531	21644	887	38	22	947
Karnataka	35251	35246	33296	32467	829	1950	5	2784
Kerala	15595	15595	13417	10323	3094	2178	0	5272
Madhya Pradesh	76013	76145	75282	75137	145	863	-132	876
Maharashtra	47476	47514	45040	46672	-1632	2474	-38	804
Manipur	17086	17259	17889	17384	505	-630	-173	-298
Meghalaya	16988	16925	16535	15633	902	390	63	1355
Mizoram	18684	18583	16397	18338	-1941	2186	101	346
Nagaland	13719	14015	13980	14164	-184	35	-296	-445
Orissa	48374	48353	49044	47033	2011	-691	21	1341
Punjab	1558	1545	1628	1412	216	-83	13	146
Rajasthan	15850	15821	14542	13871	671	1279	29	1979
Sikkim	3262	3262	3164	3118	46	98	0	144
Tamil Nadu	23044	23003	20992	17078	3914	2011	41	5966
Tripura	8155	8123	8869	5745	3124	-746	32	2410
Uttar Pradesh	14127	14127	10778	10756	22	3349	0	3371
Uttaranchal	24442	24460	23354	23260	94	1106	-18	1182
West Bengal	12413	12389	10392	8362	2030	1997	24	4051
Total	677088	677816	653898	637293	16605	23918	-728	39795

Source: State of Forest Report, 2005.

Figure: 5.6

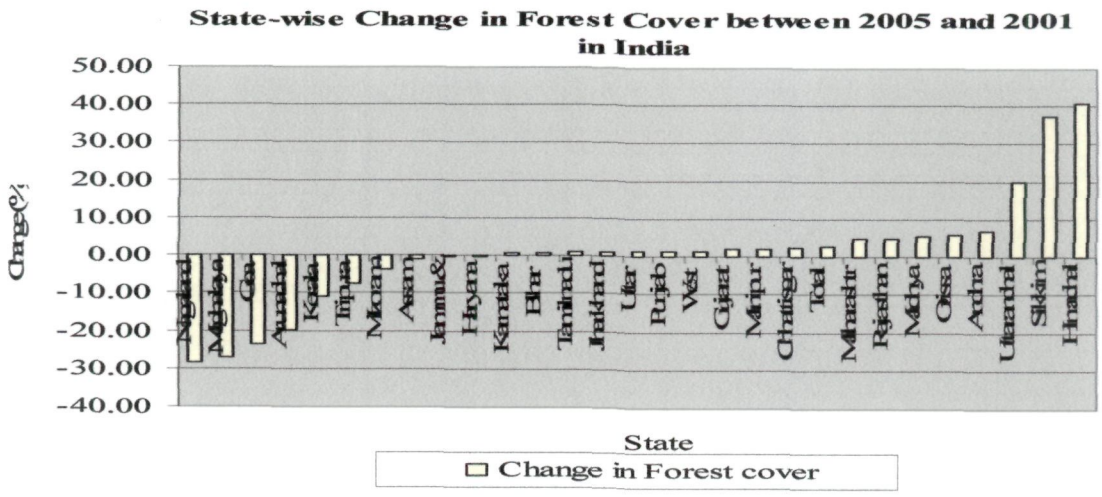


Table: 5.18
State-wise Forest Cover in India as a Percentage of Total Geographical Area

States	2001	2005	Change (3)-(2)
1	2	3	4
Nagaland	80.49	52.05	-28.44
Meghalaya	69.48	42.34	-27.14
Goa	56.59	33.06	-23.53
Arunachal Pradesh	81.25	61.55	-19.70
Kerala	40.04	28.99	-11.05
Tripura	67.38	60.02	-7.36
Mizoram	82.98	79.30	-3.68
Assam	35.33	34.21	-1.12
Jammu & Kashmir	9.56	9.10	-0.46
Haryana	3.97	3.53	-0.44
Karnataka	19.29	19.96	0.67
Bihar	6.07	6.87	0.80
Tamilnadu	16.52	17.59	1.07
Jharkhand	28.4	29.61	1.21
Uttar Pradesh	5.71	6.97	1.26
Punjab	4.83	6.12	1.29
West Bengal	12.05	13.38	1.33
Gujarat	7.73	9.67	1.94
Manipur	75.81	78.01	2.20
Chhattisgarh	41.75	44.21	2.46
All India	**20.55**	**23.41**	**2.86**
Maharashtra	15.43	20.13	4.70
Rajasthan	4.78	9.49	4.71
Madhya Pradesh	25.07	30.72	5.65
Orissa	31.36	37.34	5.98
Andhra Pradesh	16.23	23.20	6.97
Uttaranchal	44.76	64.79	20.03
Sikkim	45	82.31	37.31
Himachal Pradesh	25.79	66.52	40.73

Source: Forest Survey of India, Dehradun. State of Forest Report, 2001 and 2005.

5.5.2. Flooding

The increasing frequency of floods in India is largely due to deforestation in the catchments areas, destruction of surface vegetation, change in land-use, increased urbanization and other developmental activities. The main reason, however, is the increased sedimentation and reduced capacity of drainage systems. Consequently, streams and rivers overflow their banks, flooding the downstream areas. These are of frequent occurrence in many parts of India, especially in hilly terrains, causing a disruption of normal life and considerable damage to the

productive land system. The problem of human-induced water logging in India is more common in canal command areas (surface irrigation) because irrigation facilities are often introduced without adequate provision for drainage.

5.6. Valuation of Environmental Costs

Parikh and Parikh (2001) pulling the four estimates together estimated the economy wide cost of environmental degradation which is applicable to mid 1990s. Table: 5.19 show that we should subtract an additional 3.58 to 4.99 percent of GDP from our NDP to obtain an environmentally adjusted NDP. What does this imply for the growth rate of India's environmentally adjusted NDP?

Table: 5.19
Annual Costs of Environmental Degradation in India, 1994-1997

Resource (Percent of GDP)	Range
Air	0.40*
Forests	1.10 – 1.60
Soil	0.30 – 0.80
Water	1.70 – 2.10
Total	3.50 – 4.90

* Does not include damages due to indoor pollution
Source: Adopted from Parikh, J. and Parikh, K. (2001), Environmentally Adjusted GDP, Report to the United Nations University.

It would depend on whether damage to environment and natural resources is accelerating or not? If, as a percent of NDP the cost of environmental degradation has remained the same in past years, then the growth rate is not affected. On the other hand, if the cost of degradation was nil 5 years ago and is now 5 percent of GDP, the growth rate of NDP over the five year has to be reduced by 5 percentage points.

We should, however, emphasize that the estimated costs are partial and the cost to social welfare is likely to be much larger.

Use of different methods is necessary because of the complexity of the problem of valuation and lack of needed data. Other, the availability of data guides what methods could be used. These limitations have to be kept in mind. Nonetheless these rough estimates are enough to suggest that costs of environmental degradation can no longer be neglected as they are not small. If we do so we would be taking many wrong decisions and social welfare would not be as high as it could be. We have accumulated a backlog of environmental problems for later years that will require billions of rupees for cleaning air and water, ameliorating soils, planting forests and cleaning up landfills and mountains of garbage. Hazardous waste may have caused considerable damage to water and soil and lead to reduction in agricultural income and deformed children and diseases.

5.7. Concluding Remarks

India's environment as reflected in Land, air, water and forests resources are considerably degraded. Use of modern technology in farming sector has damaged its soil and water resources. Intensive use of land and water resources made possible by modern technology has resulted in over-exploitation of these resources. Increasing level of air pollution particularly in urban areas is posing health problems. The main sources for air pollution are growth in vehicles and rapid industrialization. Due to poverty, low income and illiteracy in rural areas of India, people use traditional sources of energy for cooking and lighting. This is causing indoor air pollution in rural areas of India. The poor are main victims of

environment related diseases (Acute respiratory infection, TBs, etc.) due to such indoor air pollution as they are more exposed than the rich.

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CHAPTER-VI

POPULATION, POVERTY AND ENVIRONMENTAL SUSTAINABILITY: AN INTER-RELATIONSHIP

6.1. Introduction

The first comprehensive report entitled "Our Common Future" by the World Commission on Environment and Development in 1987 caught attention of the Governments worldwide to the importance of 'sustainable development'. Since then countries across the globe have been incorporating the concept of sustainable development in their developmental agenda more vigorously. Poverty and population have been observed as main factors leading to unsustainable use of natural resources which, in turn, affect the lives of the poor people adversely. Hence, sustainable development entails ending poverty and improving demographic features simultaneously. India is the second most populous country of the world after China. Its population is more than 1billion. It is also home to more than 301 million poor according to the official definition of poverty line. The four BIMARU states viz. Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh are among the largest states of India in terms of both poverty and population. They together housed 106.62 million poor out of total 238.50 million poor of India in 2004-05. The combined population of the four BIMARU states was 366.02 million, around 35.6 percent of India's total population of 1028.73 million in the year 2001.

The poverty-environment linkage in the developing countries has been gaining increasing attention of the international development agencies and policy makers (Angelsen, 1997). As per the Brundtland Report, poverty is a major cause

and effect of global environmental problems (World Commission on Environment and Development, 1987). The poor are the victims as well as agents of environmental degradation. They are short-sighted and basically short-run maximisers. They try to meet the needs of the present at the cost of the future. The poor and hungry often destroy their immediate environment for their survival. They cut down forests; their livestock overgraze grasslands; they overuse marginal lands; and they crowd into congested cities in growing numbers. The cumulative effect of these changes is so far-reaching as to make poverty itself a major global scourge. It is in this context that the first report on Human Development terms poverty as one of the greatest threats to the environment (UNDP, 1990).

The rural poor in developing countries are heavily dependent on local natural resources for their sustenance (Cavendish, 2000; Jodha, 2000; Shiva & Verma, 2002; Escobal and Aldana, 2003; Gupta & Veld, 2005). Due to weak property rights and limited access to credit, insurance and capital markets, rural poverty leads to resource degradation in multiple ways (Dasgupta and Mäler, 1994; Mäler, 1997; Swinton, Escobar and Reardon, 2003; Bahamondes, 2003). The poor are heavily dependent on the open access resources like the forests, pastures, water resources that leads to their over exploitation (Jodha, 2000). Animals like sheeps or goats that act as capital resources for the rural poor degrade the vegetation and soil faster than the livestock of the richer rural population like buffaloes (Rao, 1994). Cultivable land also degrades quickly because the poor lack investment capacity for maintaining the soil quality that erodes the soil fertility (Reardon and Vosti, 1995). Since the environment as in the most developed

countries is not an amenity but a necessary input for the rural households, environmental degradation implies a shrinking input base for the poor households that increase the severity of poverty (Mink, 1993; Jodha, 2000). This cyclical relationship is commonly referred to as the poverty-environment nexus (Nelson and Chomitz, 2004; Dasgupta et al., 2003; Duraiappah, 1998).

The relationship between poverty and environment has been analyzed in the literature mostly by descriptive and empirical studies. Ikefuji and Horii (working paper - 2005) is the only study that provides a formal (dynamic mathematical) model to depict the poverty - environment trap. They show that the income distribution plays a crucial role in shaping the poverty-environment relationship.

The poverty-environment linkage has often been mentioned in the "sustainable development" debate and is seldom systematically explored (Lele, 1991). The literature that treats the linkage usually focuses on the 'vicious circle' between poverty and environmental degradation; the circle is Malthusian in inspiration where farmers pushed by population increase and poverty extend cropping onto fragile marginal lands and degrade them. As a result the yield is reduced and this further impoverishes farmers (Pearce and Warford, 1993; Mink, 1993; Dasgupta and Maler,1994).

The various studies conducted worldwide reveal that there is a two-way linkage between poverty and environmental degradation. Degradation of environment caused either by the poor or the rich has both direct and indirect impacts not only on the cost of production but also on the productivity of crops and

hence on the income of the people. Poor get more affected than the rich and become poor due to environmental degradation manifested through destruction of forest for fuel wood, timber, *jhum* cultivation; degradation of land water through the use of chemical fertilizers, pesticides, etc in modern farming; and pollution of air due to consumption of biomass fuel. Thus a vicious link is established between poverty and environmental degradation. Each becomes the cause and effect of the other.

Despite the dominant view in the literature that poverty causes environmental degradation, there is some contradicting empirical evidence. Some studies show that traditional communities have managed the resources efficiently despite their poverty (Tiffen Mortimore & Gichuki, 1994) while others show that it is not the poor but the non-poor population that deplete the rural environment (Ravnborg, 2003). Hence the effect of poverty on the environment is an empirically testable issue. We want to test the hypotheses that poverty spurs environmental degradation and environmental degradation spurs poverty.

There are several limitations of the above-mentioned studies. Most of these studies focus on the effects of poverty on environment or infer about the other direction of the relationship on the basis of extent of dependence of rural households on natural resources. This study attempts to fill in the gap in the literature by directly analyzing the effects of poverty on forests, rainfall and temperature and effects of forests and rainfall on poverty.

The objectives of the present study are to test the validity of poverty-environmental degradation hypotheses and poverty-population hypothesis.

Empirical validation of the rural poverty-environment nexus has profound policy implications for country like India which has not only large population size but also large number of poor people. It is important for policies geared to improve environmental quality to take into consideration the effect of poverty on environmental quality. Similarly, policies aimed at reducing poverty should also take into consideration the impact of environmental quality on poverty. Existence of a poverty-environment nexus therefore implies that the policies often fail to treat these two issues in a unified framework. Since, the poverty-environment nexus hypothesis argues that there is a cyclical relationship between rural poverty and environmental degradation; it implies that poverty change and environmental change are jointly determined. Yet, in spite of the assertion of the existence of such a nexus the empirical studies have not accounted for this joint endogeneity. Failure to account for the endogeneity can provide biased results.

The present study is an attempt to quantify the magnitude of both poverty and environmental degradation over time and across states in India and verify empirically the link between them. Though estimates are available on poverty for both rural and urban areas of the country and the nature of environmental degradation varies from rural to urban areas, the present study is confined to rural areas only. Forests, rainfall and temperature have been taken as variables representing the environment. The present study also attempts to test whether there is a vicious circle in operation in rural area of India.

6.2. Concepts of Sustainable Development

Thousands of years ago the Romans used the word "sustinere" which is

the source of the modern English word "sustain". The Latin word "sustinere" is compounded with 'sus/sub' (from below) plus 'tenere' (to hold) with original meaning of "to hold up" (hold from below) – a notion a bit like the English word "support" (www.ibiblio.org). In normal usage, "sustain" means to do something (i.e. nourish, support or provide the necessities of life) so that some other thing or process can be kept going for an extended period of time. So, "sustainability" means the ability to sustain or maintain (Macquaries Dictionary).

Sustainability, broadly defined, could be considered a recent manifestation of Aldo Leopold's 'Land Ethics' in his remarkable book "A Sand County Almanac". Half a century ago, Leopold (1949) argued that it is the health of eco-systems that is of paramount importance: an environmental policy or for that matter human activity is right if it preserves the integrity of an eco-system and wrong if it doesn't. This philosophy is perfectly consistent with natural resources use, provided the use doesn't degrade the eco-system. Thus fishing is acceptable but over fishing is not. Logging is acceptable, provided the long term health of the forest eco-system is not jeopardized. This view is logical predecessor to what today is called sustainability-use the environment for human needs only to the extent that the long term health of the environment doesn't suffer.

One of the best known definitions of "sustainability" was generated by the Brundtland Commission (1987), formerly the World Commission on Environment and Development. The Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs". It contains within it two key

concepts: (i) the concept of 'needs' , in particular the essential needs of the world's poor, to which overriding priority should be given; and (ii) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. It observed: many parts of the world are caught in a vicious downward spiral – poor people are forced to overuse environmental resources to survive from day to day, and the impoverishment of their environment further impoverishes them, making their survival even more difficult and uncertain. The debate over 'sustainability' has focused on two key aspects: (1) the degree to which "natural capital" can be viably replaced by human capital, and (2) the obligations, the present generation owes to the future generations. Hence, human beings are the centre stage of the notion of 'sustainable development'.

Nobel Laureate Robert Solow defines sustainability as making sure that the next generation is as well off as the current generation and ensuring that this continues for all time (Solow, 1992). Key to this view is that man made capital (machines, building, etc.), knowledge and skills are substitutes for natural capital, particularly natural resources. As man depletes the energy implicit in natural resources of the world, he invents ways of getting along with less energy and builds machines that reduce energy use or extract energy from the sun.

The central idea implicit in the concept of "sustainable development" is that while satisfying our material wants we have to shoulder the responsibility of ensuring the same material satisfaction to all the coming generations. Man has no independent existence of his own. He is dependent on environment not only for his

material satisfaction but also for his very survival. Reckless use of the environment would only limit his capabilities of satisfying his material wants. Hence, while using the environment for productive purposes, he has to ensure that no damage is done to the health of the environment.

6.3. Measuring Environmental Health in India

Forests, Rainfall and the Quality of the Environment

Forests play an important role in providing raw materials to industries and generating income and employment. Forests also help in improving the quality of the environment by influencing the ecological balance and life support system (checking soil erosion, maintaining fertility, conserving water, regulating hydro-cycles, and floods, balancing carbon-dioxide and oxygen in right proportion in atmosphere etc.). They moderate the influence of floods and thus abate the soil erosion. Forests assume special importance in the BIMARU states in view of the large scale soil erosion due to floods every year.

Forests area and cumulative area diverted for non-forest use has been growing since the Enforcement of Forest Conversion Act, 1980. Forests area diverted for non-forests use has grown from 1331.70 ha. in 1981 to 33079.50 ha. in 2004. The annual average trend growth rate of forest area diverted for non-forest use was 3110.56 ha. during 1981-04. Similarly, the cumulative area diverted for non-forest use rose from 1331.70 ha. in 1981 to 954839.03 ha. in 2004. The annual average trend growth rate of cumulative area diverted for non-forest use was 39528.80 ha. during 1981-04 (Table: 6.1).

Table: 6.1
Diversion of Forest Land (hectare) for Non-forest Use since the Enforcement of Forest Conservation Act, 1980

Year	Forest Area Diverted	Cumulative Area Diverted
1980	Nil	Nil
1981	1331.70	1331.70
1982	3674.32	5006.02
1983	5100.51	10106.53
1984	9348.90	19455.43
1985	7676.83	27132.26
1986	9310.45	36442.71
1987	25925.97	62368.68
1988	4868.71	67237.39
1989	66768.09	134005.48
1990	127361.79	261367.27
1991	5065.35	266432.62
1992	21756.77	288189.39
1993	16182.51	304371.90
1994	59962.02	36433.92
1995	51428.98	41562.90
1996	32862.55	448625.45
1997	24738.43	47363.88
1998	18425.21	491789.09
1999	45784.41	537573.50
2000	22386.43	559959.93
2001	267897.61	827857.54
2002	51172.31	879029.85
2003	42729.68	921759.53
2004	33079.50	954839.03
Annual trend growth rate	**3110.56**	**39528.80**

Source: Forests & Wildlife Statistics, India, 2004, Ministry of Environment and Forests.

Scientists recommend for the forest cover of at least 33 percent of total land mass for avoiding any climate change and ecological disturbance. Only two states out of fifteen major states of India-Kerala and Assam- had more than 33 per cent forest cover of their total geographical area in 2003. Most of the other states fall very much short of this standard. Three out of the five BIMARU states Bihar, Rajasthan, and Uttar Pradesh had less than 6 per cent forest cover of their total geographical area. 10 out of 16 major states recorded fall in the areas of forest cover in the year 2003 as compared to that in 2001. Four out of five BIMARU

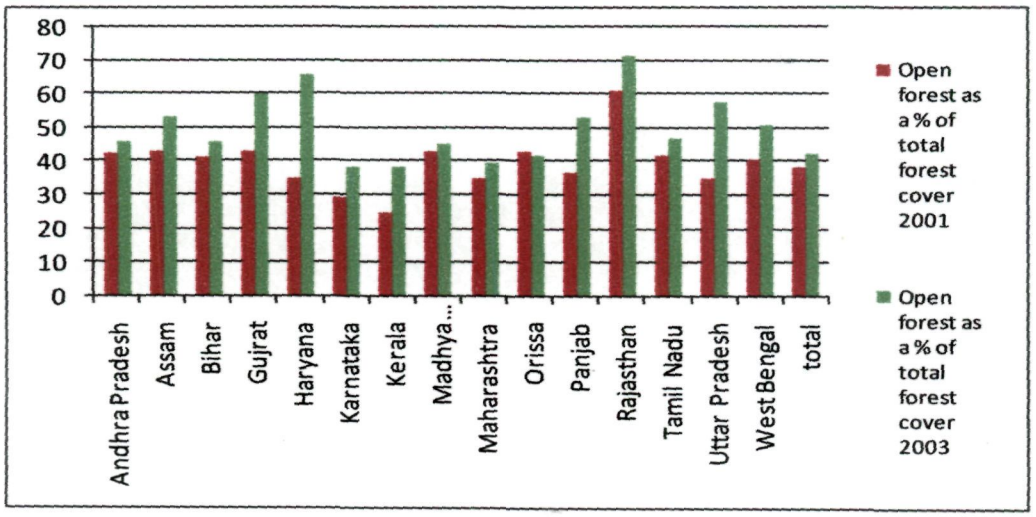
states, namely Bihar, Madhya Pradesh, Rajasthan and Orissa registered a decline in the area of forest cover over the period 2001-03 (Table: 6.2).

Table: 6.2
Forests Cover in Major States of India

States	Forest cover (% of G.A.)	Forest cover (% of G.A.)	Change in % cover	Open forest as a % of total forest cover	Open forest as a % of total forest cover	Change in % cover
	2001	2003		2001	2003	
1	2	3	4	5	6	7
Andhra Pradesh	16.23	16.15	-0.08	42.1	45.5	3.4
Assam	35.33	35.48	0.15	42.9	53.1	10.2
Bihar	6.07	5.9	-0.17	41	45.5	4.5
Gujrat	7.73	7.63	-0.1	42.8	59.9	17.1
Haryana	3.97	3.43	-0.54	35.1	65.7	30.6
Karnataka	19.29	19	-0.29	29.3	38.4	9.1
Kerala	40.04	40.08	0.04	24.3	38.2	13.9
Madhya Pradesh	25.07	24.79	-0.28	42.6	45.3	2.7
Maharashtra	15.43	15.23	-0.2	34.9	39.4	4.5
Orissa	31.33	31.06	-0.27	42.7	41.8	-0.9
Panjab	4.83	3.14	-1.69	36.3	53	16.7
Rajasthan	4.78	4.62	-0.16	61.4	71.6	10.2
Tamil Nadu	16.52	17.41	0.89	41.8	47	5.2
Uttar Pradesh	5.71	5.86	0.15	34.8	57.5	22.7
West Bengal	12.05	13.91	1.86	40.7	51	10.3
Total	20.55	20.64	0.09	38.3	42.4	4.1

Source: Forest Survey of India, Dehradun. Forest Report 2001 and 2003.
Note: Columns 4, 5, 6, and 7 have been computed. G.A: Geographical Area.

Figure: 6.1
Area of Open Forests Cover as a Percentage of Total Forests Cover in 2001 and 2003



If we take open area of forest as a percentage of total forest cover as a measure of qualitative change in the forests we find that there has been perceptible deterioration in the quality of forests in all the states except Orissa which recorded an improvement in 2003 in comparison to that in 2001 (Figure: 6.1).

Rainfall

Regularity in rainfall assumes importance in view of the fact that net irrigated area in India was only around 58.54 percent in 2004-05 (Ministry of Agriculture). The modern technology used in agriculture is irrigation intensive. Crop yields significantly increase when use of modern technology is accompanied by proper irrigation facilities. Inadequate forests coverage area in most of the states in India combined by environmental pollution as a result of industrial, vehicular

Table: 6.3
All India Rainfall Distribution from 1992-93 to 2007- 08
(In Millimeters)

Year	Overall rainfall (June-May)		
	Actual	Normal	% Departure
1992-93	1091.6	1175.6	-7.1
1993-94	1184.3	1192.6	-0.7
1994-95	1297.3	1190.7	9.0
1995-96	1154.6	1189.3	-2.9
1996-97	1195.5	1190.3	0.4
1997-98	1291.5	1198.3	7.8
1998-99	1275.5	1198.8	6.4
1999-00	1183.5	1197.0	-1.1
2000-01	1043.7	1195.5	-12.7
2001-02	1120.2	1196.0	-6.3
2002-03	981.4	1205.4	-18.6
2003-04	1278.0	1196.5	6.8
2004-05	891.4	1019.0	-12.5
2005-06	1017.7	1018.3	-0.1
2006-07	1133.0	1195.5	-5.2
2007-08*	1141.8	1143.3	-0.1

Note: - * Pre-Monsoon Season till 7th May, 2008.
Source: Indian Meteorological Department.

and indoor air pollution has resulted in frequent deviation of actual rainfall from normal rainfall. The departure of actual rainfall from normal rainfall seems to have become a regular phenomenon in India (Table: 6.3). In most of the years the actual rainfall has been less than the normal rainfall during 1992-93 to 2007-08.

The following table shows meteorological sub-division wise distribution of excess/normal and deficient/scanty rainfall in India during 1989 to 2007. The number of sub-divisions which witnessed deficient/scanty rainfall has increased from the year 1999 onwards. There were twenty one sub-divisions which registered deficient/scanty rainfall in 2002 (Table: 6.4).

Table: 6.4
Performance of South West Monsoon during 1989 to 2007
(1 June - 30 September)

Year	Number of Meteorological Sub-Divisions @	
	Excess/Normal Rainfall	Deficient/Scanty Rainfall
1989	29	6
1990	32	3
1991	27	8
1992	32	3
1993	31	4
1994	25	10
1995	33	2
1996	32	3
1997	32	3
1998	33	2
1999	28	7
2000	28	7
2001	30	5
2002	15	21
2003	33	3
2004	23	13
2005	32	4
2006	26	10
2007	30	6

Note: - Excess: + 20% or more of Long Period Average Rainfall; Normal: Between + 19% and -19% of Long Period Average Rainfall; Deficient: Between -20% and -59% of Long Period Average Rainfall; Scanty: Between -60% and -99% of Long Period Average Rainfall.
Source: Indian Meteorological Department.

Table: 6.5 and Figure: 6.2 present mean, standard deviation and coefficient of variation of annual actual rainfall by meteorological subdivision during 1994-2007. West Rajasthan; Saurashtra & Kutch; Haryana, Chandigarh & Delhi; Gujarat

Table: 6.5
Mean, Standard Deviation and Co-efficient of Variation of Annual Actual Rainfall (Millimeter) by Meteorological Sub-division in India during 1994-2007

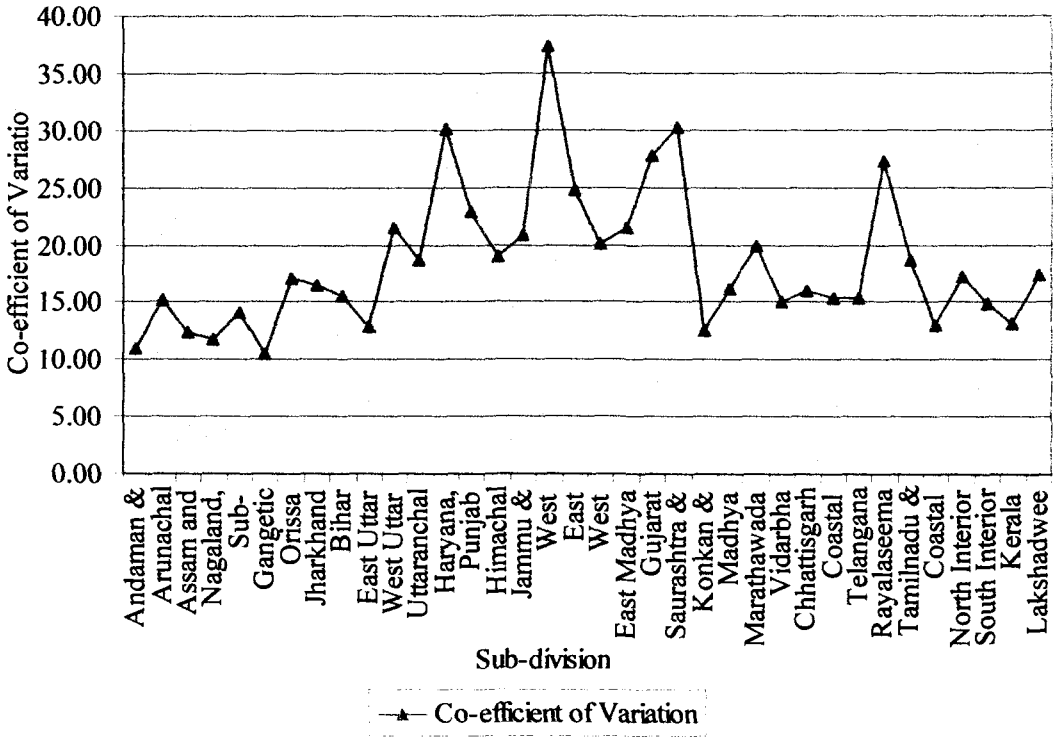
Sub-Division	Mean	S.D	C.V
Gangetic West Bengal	1596.07	168.77	10.57
Andaman & Nicobar Islands	2662.43	294.13	11.05
Nagaland, Mizoram, Manipur & Tripura	1824.21	214.13	11.74
Assam and Meghalaya	2538.00	312.92	12.33
Konkan & Goa	2956.21	372.06	12.59
East Uttar Pradesh	966.50	124.91	12.92
Coastal Karnataka	3622.36	471.63	13.02
Kerala	2957.64	387.66	13.11
Sub-Himalayan West Bengal & Sikkim	2688.50	379.61	14.12
South Interior Karnataka	1120.00	167.52	14.96
Vidarbha	1097.93	164.66	15.00
Arunachal Pardesh	2659.50	404.05	15.19
Telangana	974.21	149.91	15.39
Coastal Andhra Pradesh	1083.71	167.03	15.41
Bihar	1223.64	190.70	15.58
Chhattisgarh	1331.60	212.77	15.98
Madhya Maharashtra	944.50	153.01	16.20
Jharkhand	1355.29	223.03	16.46
Orissa	1510.57	258.97	17.14
North Interior Karnataka	713.07	123.33	17.30
Lakshadweep	1655.86	287.18	17.34
Tamilnadu & Pondicherry	974.64	181.20	18.59
Uttaranchal	1606.93	299.70	18.65
Himachal Pardesh	1148.93	218.83	19.05
Marathawada	800.57	158.94	19.85
West Madhya Pradesh	971.36	194.53	20.03
Jammu & Kashmir	1009.43	210.15	20.82
East Madhya Pradesh	1199.50	256.90	21.42
West Uttar Pradesh	812.50	174.37	21.46
Punjab	637.00	146.15	22.94
East Rajasthan	654.79	162.57	24.83
Rayalaseema	789.57	215.41	27.28
Gujarat Region	1178.00	326.69	27.73
Haryana, Chandigarh & Delhi	658.64	198.74	30.17
Saurashtra & Kutch	578.71	174.80	30.21
West Rajasthan	342.07	127.96	37.41

Source: Indian Meteorological Department.

Region; Rayalaseema; East Rajasthan; Punjab; West Uttar Pradesh and East Madhya Pradesh subdivisions experienced highest variation in actual rainfall during 1994-2007. Most of the sub-divisions belonging to BIMARU states seem to have witnessed high variation in rainfall during 1994-2007. Gangetic West Bengal; Andaman & Nicobar Islands; Nagaland, Mizoram, Manipur & Tripura; Assam and Meghalaya; Konkan & Goa subdivisions experienced lowest variation in actual rainfall during 1994-2007. The rest of the subdivisions experienced moderate variation in rainfall during the same period.

Figure: 6.2

Co-efficients of Variation of Annual Actual Rainfall by Meteorological Sub-division during 1994-2007



6.4. Impact of Environmental Change on Poverty

We analyse data on rainfall and temperature in order to test the change in environmental quality in BIMARU states and North-eastern states of India between 1991 and 2001. We use a simple regression analysis to explore whether the average rainfall and dispersion in temperature witnessed a significant change in BIMARU states and North-eastern states of India during 1991-2001. The BIMARU states here comprise Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan and Orissa. In each of these states more than 60 percent people in rural areas are dependent on agriculture and allied sectors. And 50 percent people in rural areas of BIMARU states are below poverty line. Similar was the situation in the North-eastern states of India during 1991-2001. Most of these states witnessed large scale deforestation during 1999-01. The BIMARU states had low area of forest coverage during the same period.

We use block level data taken from Census of India, 1991 and 2001 on rainfall and temperature. The dependent variables are 'average rainfall' and 'dispersion in temperature' defined as the difference between maximum and minimum temperature. We use two dummy variables one for the BIMARU states and the other for North-eastern states of India. This is similar to ANOVA except that we do it through dummy variables. The estimated functions for 1991 and 2001 are given below:

For 1991:

$$\text{Rainfall} = 1241.52 - 270.26\ \text{BIMARU}_{\text{dummy}} + 1150.16\ \text{North-east}_{\text{dummy}}$$

Sig. (0.000) (0.000) (0.000)

F-value sig. 0.000; $R^2 = 0.12$; $adjR^2 = 0.12$; n = 4084

For 2001:

Rainfall = 1133.58 – 350.40 $BIMARU_{dummy}$ + 846.31 $North\text{-}east_{dummy}$

Sig. (0.000) (0.000) (0.000)

F-value Sig. 0.000; $R^2 = 0.12$; $adjR^2 = 0.11$; n = 4084

For 1991:

DT = 21.24 + 0.02 $BIMARU_{dummy}$ + 6.15 $North\text{-}east_{dummy}$

Sig. (0.000) (0.971) (0.000)

F-value sig. 0.000; $R^2 = 0.06$; $adjR^2 = 0.04$; n = 3838

For 2001:

DT = 18.85 + 4.77 $BIMARU_{dummy}$ + 7.47 $North\text{-}east_{dummy}$

Sig. (0.000) (0.000) (0.000)

F-value sig. 0.000; $R^2 = 0.07$; $adjR^2 = 0.06$; n = 3838

Where, DT denotes dispersion in temperature and defined as maximum temperature minus minimum temperature in a particular year.

The coefficients of both the dummy variables are statistically significant at 1 percent level in case of rainfall. But while the coefficients of BIMARU states are negative those of North-eastern states are positive in both the year. The absolute value of coefficient of BIMARU dummy increased and that of North-eastern dummy increased between 1991 and 2001. The average amounts of rainfall in 1991 were 971.26 mm. and 2391.68 mm. in BIMARU and North-eastern states respectively. These declined to 783.18 mm. and 1979.89 mm. respectively in 2001. The average dispersion in temperature in 1991 were 21.26^0 C and 27.37^0 C in BIMARU and North-eastern states respectively which changed to 23.62^0 C and 26.32^0 C respectively in 2001. The results show that while rainfall declined in

BIMARU as well as North-eastern states, dispersion in temperature increased in the former case but slightly declined in the latter case between 1991 and 2001. And therefore we conclude that the environment has degraded in the BIMARU as well as North-eastern states of India during 1991-2001. In an agriculture based economy like India, the weather variations, particularly rainfall and temperature affect agricultural output directly and agro industrial output indirectly and thereby affects the price level, particularly, of agricultural commodities and income and employment of people dependent on agriculture and allied sectors. Hence, the fourth hypothesis that environmental degradation spurs rural poverty in India is accepted.

6.5. Population and Environmental Sustainability

Population

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Population explosion is primarily responsible for the stress on the global environment (Ehrlich and Ehrlich, 1990), and although other factors are not unimportant population growth is rapidly approaching a level above the earth's long-term capacity to sustain it. The growth of humanity during the twentieth century has brought about major changes to environment (Whitmore et al., 1991). The significance of population, not only number but also its poor demographic features as a whole, is great as it impedes development and degrades environmental quality.

According to Malthus, a growing population increases pressure on agricultural land forcing the cultivation of land of poorer and poorer quality. The

environmental degradation lowers the marginal product of labour and, through its effect on income, reduces the rate of population growth. The result is an equilibrium population that enjoys low levels of both income and environmental quality. The modern statement of this view replaces agricultural land with non-renewable natural resources. In this model, natural resources impose a limit to economic development, with population pressures reducing the marginal product of labour as scarce natural resources are exploited more intensively.

Environmental quality itself is important, where environmental quality is measured by the stock of forests or by the absence of air and water pollution. The environment is not a factor that limits productivity as population expands, but a good whose quality is degraded by a growing population. Population pressures are often referred to as an important cause of deforestation, and air and water pollution among other things. Population pressures are considered to be an underlying cause to convert forests and woodland areas to pasture and cropland, the harvesting of logs and the gathering of fuel wood (the three sources of deforestation). Population growth also increases the demand for wood, both for timber and for fuel wood. Population growth increases the need for arable land which, in turn, encourages the transformation of forest land to other uses. Population growth also creates pressure on the assimilative capacity of the environment and cause air, water and solid-waste pollution (Cropper and Griffiths, 1994). Hence, population control can be used as a means to reduce environmental degradation.

India will become the most populous country in the world with 1.5 billion people by 2040. At present, every sixth person in the world is Indian. India has only

2.4 per cent of the world's total land area. The population density is at 313 persons per square kilometer. The population of India was 361.08 million in 1951 which rose to 1028.7 million in 2001 (Census, 2001). The average decadal growth rate of population was 21.6 per cent during 1951-61 which only slightly decreased to 21.5 per cent during 1991-01.

Trends in Population Growth

The growing population and poverty in absolute terms pose serious environmental challenges in India. Over 60 percent of the workforce in India depends on agriculture, fisheries and forests for their livelihoods and the dependence of poor on natural resources is more as compared to the rich (Census of India, 2001). There are about 100 million people in the country who live in and around forests and another 275 million for whom forests constitute an important source of livelihoods (Bajaj and Manjul, 2001). Hence, it is important to ensure environmental sustainability to protect the people against poverty in India. The reduction in population growth rate directly reduces stress on the environment.

India is the second largest country of the world in terms of population after China. Given a vast base of India's population and a high growth rate of it, pressure on natural resources will further increase. It supports 17 percent of the world population on just 2.4 percent of world land area. The annual exponential growth rate of population was 0.56 percent during 1901-1911 which reached the peak level of 2.22 percent during 1961-71. The growth rate has been continuously declining since 1961-71. It declined from 2.22 percent per annum in 1961-71 to 1.95 percent

per annum in 1991-01. The current rate of population growth in India is 1.85 percent which is considered to be a high growth rate. (Table: 6.6).

Table: 6.6
Population Growth in India over the Years

Average Annual Percentage Growth Rate			
Period	Arithmetic	Geometric	Exponential
1901-11	0.57	0.56	0.56
1911-21	-0.03	-0.03	-0.03
1921-31	1.10	1.05	1.04
1931-41	1.42	1.34	1.33
1941-51	1.33	1.26	1.25
1951-61	2.16	1.98	1.96
1961-71	2.48	2.24	2.22
1971-81	2.47	2.23	2.20
1981-91	2.38	2.16	2.14
1991-01	2.15	1.97	1.95

Note: 1991 Population includes interpolated population figures for J & K.
Source: Population from General Population Table (Part II-A), Census of India 1991 for data (1901-1911) to (1971-81). Primary Census Abstract Census of India 2001 for data from (1981-1991 to 1991-2001).

In the report of the Technical Group on Population Projections constituted by the National Commission on Population, India's population was projected to be 1400 million by 2026. Population density of India will be steadily increasing up to 2026. It will increase from 313 persons per square kilometer in 2001 to 426 in 2026. (Table: 6.7).

Table: 6.7
Population projections (in millions) in India

Year	2001	2006	2011	2016	2021	2026
Population density	313	338	363	386	408	426
Below 15 years	365*(364)	357	347	340	337	327
15-64 years	619*(613)	699	780	851	908	957
Above 65 years	45*(49)	56	66	78	95	116
Total population	1,029	1,112	1,193	1,269	1,340	1,400

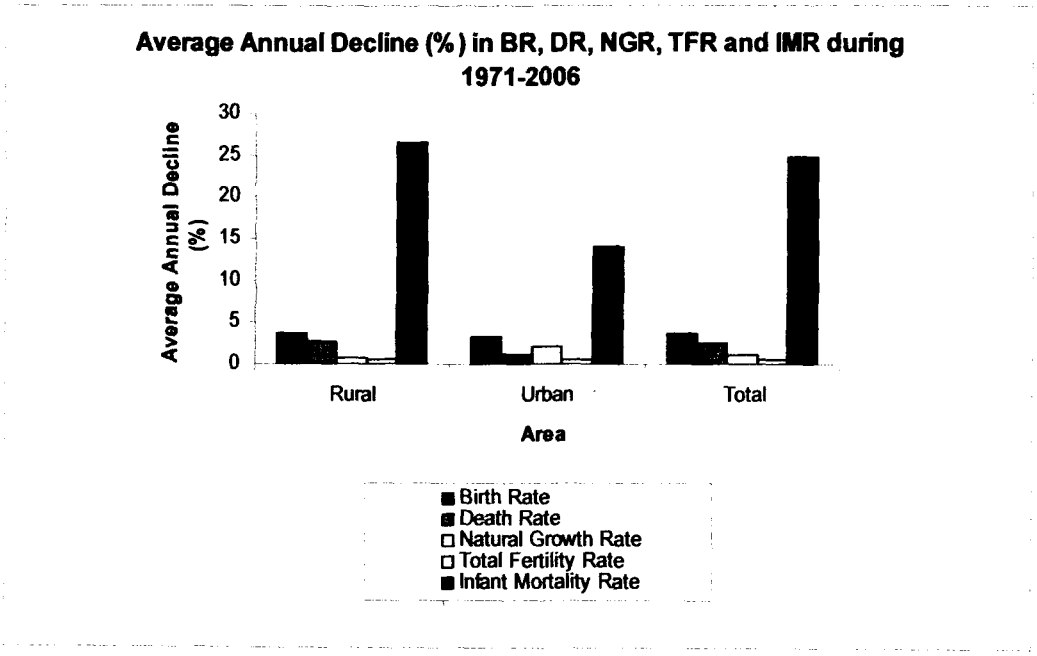
Notes: Population is in thousand and density is in persons Per Sq. Km. Figures are as per smoothing of age-groups for working out population projections. Figures in parenthesis are as per Census of India 2001. These figures will not tally with the total since 'age not stated' is excluded.
Source: Population Projections for India and States 2001-2026 - Census of India 2001: Report of the Technical Group on Population Projections constituted by the National Commission on Population, May 2006.

The decline in land-man ratio is likely to increase the rate of deforestation and overuse of other natural resources. This increasing burden of population on natural resources is likely to make the poor people even more vulnerable to poverty as they are more dependent on natural resources than the rich ones.

Table: 6.8
Average Annual Declining Trends in Birth Rate, Death Rate, Natural Growth Rate, Total Fertility Rate and Infant Mortality Rate in India

	Birth Rate	Death Rate	Natural Growth Rate	Total Fertility Rate	Infant Mortality Rate
Sector	1971-2006	1971-2006	1971-2006	1971-2005	1971-2006
Rural	3.61	2.78	0.82	0.67	26.41
Urban	3.38	1.12	2.16	0.57	14.10
Total	3.68	2.49	1.18	0.68	24.74

Figure: 6.3



The birth and death rates together determine the growth rate of population in a country. It can be seen from table: 6.8 that average annual declining trends in birth rate, death rate, total fertility rate and infant mortality rate have been higher in rural areas than in urban areas of India during 1971-2006. The birth rate, death rate,

total fertility rate and infant mortality rate declined at the average annual rate of 3.61, 2.78, 0.67 and 26.41 in rural areas respectively. These rates of decline were 3.38, 1.12, 0.57 and 14.10 respectively in urban areas during the same period. But rate of decline in natural growth rate was much lower in rural areas than in urban areas during 1971-2006 (Table: 6.8 and Figure: 6.3). It is here remarkable that high infant mortality leads to population growth in India. The reason is that for the poor children are like assets. To ensure income security in old age, the poor over-compensate by bearing too many children which leads to population growth.

Table: 6.9
Population and its Growth Rate in Major States of India

States	Population (in lakh)		Decadal growth rate of population (percent)					Mean decadal growth rate
	1951	2001	1951-61	1961-71	1971-81	1981-91	1991-01	
1	2	3	4	5	6	7	8	9
Tamil Nadu	30.11	62.40	11.80	22.30	17.50	15.40	11.70	15.74
Kerala	13.54	31.84	24.80	26.30	19.20	14.30	9.40	18.80
Andhra Pradesh	31.11	76.21	15.60	20.90	23.10	24.20	14.60	19.68
Orissa	14.64	36.80	19.80	25.00	20.20	20.10	16.30	20.28
Punjab	9.16	24.35	21.50	21.70	23.90	20.80	20.10	21.60
Karnataka	19.40	52.85	21.60	24.20	26.70	21.10	17.50	22.22
Uttar Pradesh	60.27	166.19	16.40	19.50	25.40	25.60	25.80	22.54
Bihar	29.08	82.99	19.80	20.90	24.20	23.40	28.60	23.38
Maharashtra	32.00	96.87	23.60	27.50	24.50	25.70	22.70	24.80
West Bengal	26.30	80.17	32.80	26.90	23.20	24.70	17.80	25.08
Gujrat	16.26	50.67	26.90	29.40	27.70	21.20	22.70	25.58
Madhya Pradesh	18.61	60.34	24.70	29.30	27.20	27.20	24.30	26.54
Assam	8.02	26.65	35.00	35.00	23.40	24.20	18.90	27.30
Rajasthan	15.97	56.50	26.20	27.80	33.00	28.40	28.40	28.76
Haryana	5.67	21.14	33.80	32.20	28.80	27.40	28.40	30.12
India	361.10	1028.70	21.60	24.80	24.70	23.90	21.50	23.30
S.D.	13.69	37.00	6.72	4.46	3.92	4.14	6.06	—

Source: Column 4, 5, 6, 7, 8 and 9 were computed on the basis of data on population from Primary Census Abstract, 2001.

The population of India was 361.08 million in 1951 which rose to 1028.7 million in 2001 (Census of India, 2001). The average decadal growth rate of population was 21.6 per cent during 1951-61 which only slightly decreased to 21.5

per cent during 1991-01. The decadal growth rates are much higher in poor and/or heavily populated states of India. The highest mean decadal growth rate of population was in Haryana followed by Rajasthan, Assam, Madhya Pradesh, Gujarat, West Begal, Maharashtra, Uttar Pradesh and Bihar with mean decadal growth rates of 28.76, 27.3, 26.54, 25.58, 25.08, 24.8, 22.54 and 23.38 respectively. (Table: 6.9).

Population and poverty are closely interlinked and they in fact reinforce each other making it difficult for the poor to come out of poverty and/or contribute to population control. Poverty is considered to be both cause and effect of environmental degradation. The circular link between poverty and environment is assumed to be an extremely complex phenomenon. Poverty and inequality foster un-sustainability because the poor, who rely on natural resources more than rich, deplete them faster as they have no real prospects of gaining access to other types of resources. Moreover, degraded environment can accelerate the process of impoverishment again because the poor depend directly on natural resources.

The growing population and poverty in absolute terms pose serious environmental challenges in India. Over 60 percent of the workforce in India depends on agriculture, fisheries and forests for their livelihoods and the dependence of poor on natural resources is more as compared to the rich (Census of India, 2001). The growth in population in such a setting increases pressure on land and other natural resources which leads to unsustainable use of them. There are about 100 million people in the country who live in and around forests and another 275 million for whom forests constitute an important source of livelihoods (Bajaj

and Manjul, 2001). Hence, it is important to ensure environmental sustainability to protect the people against poverty in India. The reduction in population growth rate directly reduces stress on the environment. However, between population and environment there are many social, economic, technological and political factors which play vital intervening roles (Commoner, 1990), and these are easier to modify, at least in the short-run than current rates of population growth.

Table: 6.10
Relationship between Poverty and Population Growth

State	Mean poverty ratio	Annual exponential growth rate (%) of population
	1973-74 to 2004-05	1971 to 2005
Andhra Pradesh	24.88	1.74
Arunachal Pradesh	36.31	2.58
Assam	30.28	1.88
Bihar	45.15	2.15
Chhattisgarh	40.39	1.85
Goa	20.48	1.72
Gujarat	27.68	2.02
Haryana	28.77	2.35
Himachal Pradesh	19.88	1.75
Jammu & Kashmir	27.51	2.42
Jharkhand	44.10	2.02
Karnataka	29.56	1.83
Kerala	21.79	1.24
Madhya Pradesh	42.54	2.22
Maharashtra	36.84	2.05
Manipur	30.12	2.15
Meghalaya	35.76	2.51
Mizoram	35.16	2.96
Nagaland	55.78	4.00
Orissa	42.85	1.61
Punjab	20.04	1.83
Rajasthan	34.93	2.47
Sikkim	35.45	2.85
Tamil Nadu	27.76	1.29
Tripura	32.56	2.20
Uttar Pradesh	39.36	2.18
Uttarakhand	39.14	2.01
West Bengal	34.88	1.84
All India	34.68	1.98
Correlation Co-efficient	**0.57**	

Source: Population growth rate has been calculated by using data on population in 1971 and 2005 from Projected Population by Office of the Registrar General, India, based on Final Population Totals, Census of India, 2001. Mean Poverty Ratio has been calculated from data on poverty from Planning Commission. Poverty ratio in 2004-05 is based on Uniform Recall Period (URP).
Note: - Correlation-coefficient is statistically significant at 1 percent level.

The correlation coefficient between mean poverty ratio during 1973 to 2004-05 and annual exponential growth rate in population during 1971 to 2005 of all the 28 states of India is 0.57 which is positive and statistically significant at 1 percent level (Table: 6.10). Hence, this is evidence in support of the argument that the poorer the state the larger has been the population growth rate in India during 1971 to 2005. Therefore, we conclude from this that poverty is a determinant of population growth and for the same reason we accept the first hypothesis that poverty leads to population growth in India. A number of socio-economic factors like illiteracy, high infant mortality rate, preference for male children, child labour market etc. are actually by-products of poverty and they also contribute to population growth.

Table: 6.11
Common Property Resources (CPRs) and the Poor

Study	State	CPR type	As percent of Household Income
Jodha (1991)	Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu	Land	17-23%
Sarabhai et al (1991)	Four Villages in Gujarat	Forest	38.5 – 46.3% of village income from forest produce
Beck (1994)	Three Villages in Bengal	Land and Water bodies	19-29%
Nadkarni (1997)	Four Villages in Karnataka	Land and Water bodies	24.3% for poor farmers 18.1% for non-poor farmers

Growth in population leads to increase in density of population and consequently decline in land-man ratio. As a result, there is intensive use of scarce natural resources which leads to their degradation. The poor in the absence of alternative sources of income and employment overuse the environmental resources from

which they derive their livelihoods. The common property resources (CPRs) from which the poor people derive a large proportion of their income are particularly subjected to degradation under such situations.

Table: 6.12
Relationship of Population Growth Rate with Change in Forest Cover in India

States	Decadal Growth Rate (%)	Change in Forest Cover (%)
	1991-01	2001-05
Andhra Pradesh	13.86	6.97
Arunachal pradesh	26.21	-19.7
Assam	18.85	-1.12
Bihar	28.43	0.8
Goa	14.89	-23.53
Gujarat	22.48	1.94
H.P	17.53	40.73
Haryana	28.06	-0.44
J&K	29.04	-0.46
Karnataka	17.25	0.67
Kerala	9.42	-11.05
M.P	24.34	5.65
Maharashtra	22.57	4.7
Manipur	30.02	2.2
Meghalaya	29.94	-27.14
Mizoram	29.18	-3.68
Nagaland	64.14	-28.44
Orissa	15.94	5.98
Punjab	19.76	1.29
Rajasthan	28.33	4.71
Sikkim	32.98	37.31
Tamil Nadu	11.19	1.07
Tripura	15.74	-7.36
U. P	25.8	1.26
W. B	17.84	1.33
India	21.34	2.86
Correlation co-efficient	**0.27**	

Note: The correlation coefficient is statistically significant at 10 % level.
Source: Population 2001: Census of India 2001. Forest Survey of India, Dehradun, State of Forest Report, 2001 and 2005.

The pollution that the poor generate is of a different kind than generated by the rich. The poor, from lack of alternatives rely intensively on the environment for their needs. Since the poor depend heavily on the environment, its degradation affects their livelihood greatly. They thus become both victims and agents of environmental degradation as they both need (and often exploit) the environment to

survive but suffer the most when it degrades. Many micro-level studies have shown the extent of income support the poor receive from the environment (Table: 6.11).

Population growth in long run leads to increase in population density and increase pressures on natural resources. The relative importance of population growth leading to forest degradation may vary from country to country or region to region within a country. The correlation coefficient of decadal population growth rate during 1991-01 with change in forest cover during 2001-05 was found to be -0.27 which is negative as expected and statistically significant at 10 percent level (Table: 6.12). Hence, population growth over a long period of time seems to have a negative impact on change in forests cover.

Table: 6.13
Municipal Population and Waste Water Generated in Metro-cities in 1995-96

Name of Metro-city	Municipal Population	Volume of Waste Water (in MLD)
Ahmadabad	2876710	556.0
Bangalore	4130288	400.0
Bhopal	1062771	189.3
Bombay	12288519	2456.0
Kolkata	9643211	1432.2
Coimbatore	816321	60.0
Delhi	8419084	1270.0
Hydrabad	4098734	373.3
Indore	1091674	145.0
Jaipur	1458483	220.0
Kanpur	1874409	200.0
Kochi	670009	75.0
Lucknow	1619115	106.0
Ludhiana	1042740	94.4
Madras	4752974	276.0
Madurai	940989	48.0
Nagpur	1624752	204.8
Patna	917243	219.0
Pune	2244196	432.0
Surat	1498817	140.0
Vadodra	1031346	140.0
Varansi	1030863	170.0
Vishakhapatnam	752037	68.0
Total	65885285	9275.0
Correlation co-efficient	0.95	

Note: MLD-Million Litre Per Day. The correlation co-efficient is statistically significant at 1 % level.
Source: Central Pollution Control Board.

The growing urbanization is posing serious environmental problems in India. The ever growing urban transportation causes air and water pollution which largely affects the health of the urban poor and slum dwellers as they are more exposed to them than the rich. The growth in urban population leads to rise in demand for transportation and water for domestic use. As a result, air is polluted and waste water generated in metro-cities at large scale. The size of population of a metro-city and volume of waste water generation per day is highly correlated. The correlation co-efficient between them is 0.95 which is positive and statistically significant at 1 percent level (Table: 6.13).

Trends in Poverty in India

The concept of poverty is multidimensional. It covers not only levels of income and consumption, but also health and education, vulnerability and risk; and marginalization and exclusion of the poor from the mainstream of society (Dev, 2000). The performance of India in terms of non-income indicators (viz., education and health) has not been satisfactory. The BIMARU states have particularly shown poor performance in terms of non-income indicators.

India has made significant progress in poverty reduction. The percentage of people below poverty line has come down significantly. Yet, large number of persons remains below the poverty line. Poverty ratio declined from 54.88 percent in 1973-74 to 26.10 percent in 1999-00. The projected poverty ratio by the Planning Commission was 19.3 percent in 2007. The rural and urban poverty ratios in India were projected to be 21.1 percent and 15.1 percent respectively (Table: 6.14).

Table: 6.14
Percentage of People below Poverty Line in India

Year	Rural	Urban	Total
1973-74	56.44	49.01	54.88
1977-78	53.07	45.24	51.32
1983	45.65	40.79	44.48
1987-88	39.09	38.20	38.86
1993-94	37.27	32.36	35.97
1999-2000	27.00	23.62	26.10
2004-05*	21.80	21.70	21.80
2007**	21.10	15.10	19.30

Source: Planning Commission, 2000.
* MRP- Mixed Reference Period (source: www.planningcommission.nic.in).
** Poverty projection for 2007 (source: Tenth Five Year plan, Vol. I, Planning Commission).

Although, there is only a small gap between rural and urban poverty ratio, a huge gap exists in terms of absolute number of poor living in rural and urban areas. Still around 70 percent poor in India live in rural areas. The high incidence of poverty that still prevails in India underlines the need for rapid economic development to create more remunerative employment opportunities, to invest in agriculture, health and education sectors.

Trends in Rural Poverty

Approximately 72 percent of the population resides in rural areas. Hence the analysis of the relationship between rural poverty and environmental change is likely to have pronounced policy implications for sustainable development of this country.

Table: 6.15 depicts the scenario of change in rural poverty ratio across states and over time in India. Each of the twenty five states of India shows a declining trend in rural poverty ratio during 1977-78 to 2004-05. However, there is large variation in decline in poverty ratio across states. Punjab, Haryana, Uttar Pradesh, Rajasthan, Bihar, Gujarat, Himachal Pradesh, Orissa and Madhya Pradesh were the states which witnessed lowest decline in rural poverty during 1977-78 to 2004-05.

West Bengal, Kerala, J & K and North Eastern states of India witnessed highest decline in rural poverty during the same period. There is significant (at 5 percent level) positive correlation coefficient (0.73) between rural poverty ratio in 1977-78 and 2004-05. Similarly, the correlation coefficient between poverty ratio in 1977-78 and decline in poverty ratio during 1977-2004 is 0.65 which is also positive and significant at 5 percent level. Hence, although there has been mixed performance on poverty front by states, their relative positions in rural poverty ratio has not changed significantly during 1977-2004 (Table: 6.15).

Table: 6.15
State-wise Percentage of Population below the Poverty Line in Rural Areas (1977-78 to 2004-05

(In %)

States	1977-78	1987-88	2004-05 (URP)*	Change in poverty ratio 1977-78 to 2004-05
Punjab	16.4	12.6	9.1	7.3
Haryana	27.7	16.2	13.6	14.1
Uttar Pradesh	47.6	41.1	33.4	14.2
Rajasthan	35.9	33.2	18.7	17.2
Bihar	63.3	52.6	42.1	21.2
Gujarat	41.8	28.7	19.1	22.7
Himachal Pradesh	33.5	16.3	10.7	22.8
Orissa	72.4	57.6	46.8	25.6
Madhya Pradesh	62.5	41.9	36.9	25.6
Andhra Pradesh	38.1	20.9	11.2	26.9
Karnataka	48.2	32.8	20.8	27.4
Goa	37.6	17.6	5.4	32.2
Maharashtra	64.0	40.8	29.6	34.4
Tamil Nadu	57.7	45.8	22.8	34.9
Arunachal Pradesh	59.8	39.4	22.3	37.5
Assam	59.8	39.4	22.3	37.5
Manipur	59.8	39.4	22.3	37.5
Meghalaya	59.8	39.4	22.3	37.5
Mizoram	59.8	39.4	22.3	37.5
Nagaland	59.8	39.4	22.3	37.5
Sikkim	59.8	39.4	22.3	37.5
Tripura	59.8	39.4	22.3	37.5
Jammu & Kashmir	42.9	25.7	4.6	38.3
Kerala	51.5	29.1	13.2	38.3
West Bengal	68.3	48.3	28.6	39.7
All India	53.1	39.1	28.3	24.8

* URP - Uniform Reference Period.
Source: Planning Commission & NSSO Data, 61st Round.

6.6. Poverty-Environment Relationship

Poverty and Environmental Degradation Indices

To make a meaningful spatial and temporal comparison of different States of India in terms of indicators of poverty, and forests cover, the following formulae are used to arrive at the degradation index of the indicator variables as mentioned below.

$PINDEX_{it} = 1 - [Max(X_{it}) - X_{it}]/[Max(X_{it}) - Min(X_{it})]$

Where $PINDEX_{it}$ is poverty index of the i^{th} state in t^{th} year; X_{it} is the rural poverty (%) of the i^{th} state in t^{th} year; Max (X_{it}) is the rural poverty (%) of the state with maximum rural poverty (%) in t^{th} year; and $Min(X_{it})$ is the rural poverty (%) of the state with minimum rural poverty (%) in t^{th} year.

$EINDEX_{it} = [Max(X_{it}) - X_{it}]/[Max(X_{it}) - Min(X_{it})]$

Where $EINDEX_{it}$ is environment index of the i^{th} state in t^{th} year; X_{it} is the rural poverty (%) of the i^{th} state in t^{th} year; Max (X_{it}) is the forest cover (%) of the state with maximum forest cover (%) in t^{th} year; and $Min(X_{it})$ is the forest cover (%) of the state with minimum forest cover (%) in t^{th} year.

Lastly, an average composite index $PEINDEX_{it} = [PINDEX_{it} + EINDEX_{it}]/2$ was constructed using both poverty and environment indices for the purpose of comarision across states and over time where $PEINDEX_{it}$ is the poverty-environment index of the i^{th} state in t^{th} year.

Table: 6.15 depict poverty and environment indices of Indian states in year 1887-88 and 2004-05. The poverty index (PINDEX) has been formed by using rural poverty ratio of Indian states. The environment index (EINDEX) has been constructed on the basis of forest cover as a percentage of total geographical area in

different states of India.

Table: 6.16
State-wise Indices of Rural Poverty and Environment

States	Poverty Index PINDEX		Environment Index EINDEX		Poverty-Environment Index PEINDEX	
	1987-88	2004-05	1987-88	2004-05	1987-88	2004-05
Andhra Pradesh	0.18	0.16	0.80	0.76	0.49	0.46
Arunachal Pradesh	0.59	0.42	0.00	0.00	0.30	0.21
Assam	0.59	0.42	0.76	0.74	0.68	0.58
Bihar	0.89	0.89	0.97	0.94	0.93	0.92
Goa	0.11	0.02	0.72	0.63	0.42	0.33
Gujarat	0.36	0.34	0.93	0.90	0.65	0.62
Haryana	0.08	0.21	1.00	1.00	0.54	0.61
Himachal Pradesh	0.08	0.14	0.73	0.75	0.41	0.45
Jammu & Kashmir	0.29	0.00	0.36	0.43	0.33	0.22
Karnataka	0.45	0.38	0.86	0.84	0.66	0.61
Kerala	0.37	0.20	0.73	0.71	0.55	0.46
Madhya Pradesh	0.65	0.77	0.77	0.70	0.71	0.74
Maharashtra	0.63	0.59	0.85	0.83	0.74	0.71
Manipur	0.59	0.42	0.74	0.07	0.67	0.25
Meghalaya	0.59	0.42	0.57	0.55	0.58	0.49
Mizoram	0.59	0.42	0.35	0.18	0.47	0.30
Nagaland	0.59	0.42	0.39	0.42	0.49	0.42
Orissa	1.00	1.00	0.64	0.60	0.82	0.80
Punjab	0.00	0.11	0.99	0.94	0.50	0.53
Rajasthan	0.46	0.33	0.97	0.93	0.72	0.63
Sikkim	0.59	0.42	0.64	0.53	0.62	0.48
Tamil Nadu	0.74	0.43	0.86	0.83	0.80	0.63
Tripura	0.59	0.42	0.39	0.38	0.49	0.40
Uttar Pradesh	0.63	0.68	0.97	0.94	0.80	0.81
West Bengal	0.79	0.57	0.90	0.86	0.85	0.72
All India	0.59	0.56	0.80	0.76	0.70	0.66

Source: Computed using data available at http://planningcommission.nic.in.

Poverty and environment indices were measured on 0-1 scale and presented in the Table: 6.16. The higher the values of poverty index the higher the poverty level. Similarly, the higher the value of environment index the lower the forest cover and thus higher the vulnerability of environment and environmental degradation on account of this indicator. Analysis of these indices reveals that there

is large-scale state-wise variation in the incidence of poverty and environment. These individual indices also changed over time from 1987-88 to 2004-05. Particularly, poverty indices changed to a large extent in comparision to environment indices. The all India poverty index declined from 0.59 in 1987-88 to 0.57 in 2004-05. The all India Environment index also declined from 0.80 in 1987-88 to 0.76 in 2004-05. Thus both poverty and environmental degradation have significantly reduced in India during 1987-88 to 2004-05. As a result, the all India poverty-environment composite index declined from 0.70 in 1987-88 to 0.66 in 2004-05.

Table: 6.17 depict index-wise groupings of states categorized as high, moderate, and low poverty and environmental degradation. Bihar, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, and West Bengal had high poverty indices (PINDEX$\geq$ 0.60) in 1987-88 and Andhra Pradesh, Goa, Gujarat, Haryana, Himachal Pradesh, J & K, Kerala and Punjab had lowest poverty indices in 1987-88. While Maharashtra, Tamil Nadu and West Bengal witnessed reduction in poverty index, Bihar, Madhya Pradesh, Orissa and Uttar Pradesh maintained their high poverty indices in 2004-05 too. As far as the environmental vulnerability index is concerned, Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, and West Bengal had high environmental vulnerability indices (EINDEX $\geq$ 0.60) in 1987-88. The same states were also highly environmentally vulnerable in 2004-05 except Manipur. There are some mixed findings on poverty and environmental

Table: 6.17
Index-wise Groupings of States

Level of Vulnerability	Value of Index	States	
		1987-88	2004-05
High Poverty	High (PINDEX ≥ 0.60)	Bihar, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal	Bihar, Madhya Pradesh, Orissa, Uttar Pradesh
Moderate Poverty	Moderate (0.40 ≤ PINDEX < 0.60)	Arunachal Pradesh, Assam, Karnataka, Manipur Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura	Arunachal Pradesh, Assam, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tamil Nadu, Tripura, West Bengal
Low Poverty	Low (PINDEX < 0.40)	Andhra Pradesh, Goa, Gujrat, Haryana, Himachal Pradesh, J & K, Kerala, Punjab	Andhra Pradesh, Goa, Gujrat, Haryana, Himachal Pradesh, J & K, Karnataka, Kerala, Punjab, Rajasthan
High Environmental Degradation	High (EINDEX ≥ 0.60)	Andhra Pradesh, Assam, Bihar, Goa, Gujrat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal	Andhra Pradesh, Assam, Bihar, Goa, Gujrat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal
Moderate Environmental Degradation	Moderate (0.40 ≤ EINDEX < 0.60)	Meghalaya	J & K, Meghalaya, Nagaland, Sikkim
Low Environmental Degradation	Low (EINDEX < 0.40)	Arunachal Pradesh, J & K, Mizoram, Nagaland, Tripura	Arunachal Pradesh, Manipur, Mizoram, Tripura

degradation indices in some states. But most of the poor and low income states have high environmental degradation indices. Bihar, Madhya Pradesh,

Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, and West Bengal were the states which were high on both poverty and environmental degradation indices in 1987-88. But states like Andhra Pradesh, Goa, Gujarat, Haryana, Himachal Pradesh, Kerala, and Punjab which were low on poverty indices but high on environment indices in the same year. The situation was more or less same in the year 2004-05 also. The correlation coefficients between PINDEX and EINDEX in year 19887-88 and 2004-05 are -0.14 and 0.06 respectively. They are not only statistically insignificant at 10 percent level but even the sign is not expected in the former case. Thus it became too difficult on our part to draw any definite conclusion regarding the relationship between poverty and environmental degradation on the basis of above indices. One important reason for the unexpected results could be that the Government reforestation programme helped in improving the forests cover especially in forests deficit and poor states. However, the BIMARU states (Bihar, Madhya Pradesh, Uttar Pradesh, Rajasthan, and Orissa) are high on both poverty and environmental degradation indices in India. Therefore, the study partially accepts the third hypothesis which states that rural poverty increases environmental degradation.

Composite Index of Poverty and Environmental Degradation

Composite index of poverty and environmental degradation revealed that out of total twenty five states twenty states experienced improvement in composite index (PEINDEX) over the period 1987-88 to 2004-05. The rest five states witnessed deterioration in the same index. These five states were Haryana, Himachal Pradesh, Madhya Pradesh, Punjab and Uttar Pradesh. The States which

were hardest hit in 1987-88 (PEINDEX > 0.60) were Assam, Gujrat, Karnataka, Bihar, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, Manipur, Sikkim, and West Bengal. The least affected States (PEINDEX < 0.40) were Arunachal Pradesh, and Jammu & Kashmir. The rest of the States were moderately hit (0.40 < PEINDEX < 0.60). After a period of 15 years the situations, of course, changed in many respects. Most of the North Eastern States performed well on composite index over the period 1987-88 to 2004-05. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mezoram, Sikkim, and West Bengal are the states which greatly improved their composite poverty-environment indices over the period 1987-88 to 2004-05. The four BIMARU states Bihar, Madhya Pradesh Orissa and Uttar Pradesh continue to be highly vulnerable to poverty and/or environmental degradation as reflected in high composite poverty-environment index (PEINDEX). In general it can be said that the extent of progress made in the reduction of poverty and countering environmental degradation across the states in India was asymmetrical.

But rural India as a whole witnessed progress as regards composite index of poverty-environmental degradation was concerned. The overall index value improved from 0.70 in 1987-88 to 0.66 in 2004-05 in 15 years of gap from 1987-88 to 2004-05 (Table: 6.18). Moreover, the relative position of different States according to composite index did not change significantly as was evident from the high correlation coefficient (r = 0.87, significant at 1 percent) between the composite indices of environmental degradation for both the years.

Table: 6.18
Types of Waste Land as a Percentage of Total Waste Land and Rural Poverty Ratio in India in 2003

States	Saline/ alkaline area	Shifting cultivation area	Deg. Notified forest land	Deg. Pastures/ Grazing land	Deg. Land under plantation crop	Rural Poverty Ratio (%)
1	2	3	4	5	6	7
Andhra Pradesh	1.17	0.03	42.97	1.37	0.10	11.20
Arunachal Pradesh	0.00	16.85	7.73	11.65	0.03	22.30
Assam	0.00	41.92	15.55	11.08	0.00	22.30
Bihar	0.00	0.22	62.23	0.79	0.38	42.10
Goa	0.00	0.00	11.74	0.40	5.25	5.40
Gujarat	17.75	0.00	12.65	0.90	0.18	19.10
Haryana	7.65	0.00	19.62	19.33	3.59	13.60
Himachal Pradesh	0.00	0.00	14.50	13.51	7.76	10.70
Jammu & Kashmir	0.00	0.00	3.81	0.41	0.98	4.60
Karnataka	0.60	0.00	39.83	0.47	0.50	20.80
Kerala	0.00	0.00	42.07	0.28	1.77	13.20
Madhya Pradesh	0.23	0.00	29.32	0.43	1.31	36.90
Maharashtra	0.47	0.00	25.11	2.52	1.29	29.60
Manipur	0.00	92.78	4.70	0.00	0.00	22.30
Meghalaya	0.00	21.07	36.47	0.00	0.00	22.30
Mizoram	0.00	92.38	7.62	0.00	0.00	22.30
Nagaland	0.00	62.17	18.84	0.00	0.00	22.30
Orissa	0.24	0.54	46.92	0.06	0.91	46.80
Punjab	7.78	0.00	15.85	5.10	3.66	9.10
Rajasthan	2.58	0.00	11.87	11.56	0.02	18.70
Sikkim	0.00	0.00	29.71	0.00	0.00	22.30
Tamil Nadu	0.00	31.42	46.09	0.00	0.00	22.80
Tripura	10.77	0.00	41.86	0.73	0.96	22.30
Uttar Pradesh	14.99	0.00	8.61	1.15	0.13	33.40
West Bengal	2.30	0.00	13.60	6.73	0.05	28.60
All India	3.21	5.50	22.03	4.07	0.91	28.30
Correlation co-efficient	-0.01	0.02	0.41*	-0.23	-0.45*	

Source: For columns 2, 3, 4, 5, and 6 - Forestry Statistics in India, 2003. For column 7- Planning Commission & NSSO Data, 61st Round. Rural poverty ratio is based on uniform recall period (URP) in 2004-05.
Note: The correlation co-efficient of each type of land degradation with rural poverty ratio is given in the corresponding column. * denotes that the correlation co-efficients are statistically significant at 5 % level.

Table: 6.18 present types of waste land as a percentage of total waste land area and rural poverty ratio. Degraded forests land constitutes the largest percentage of total waste land area in India followed by shifting cultivation area, grazing land, saline area and degraded land under plantation. The correlation co-efficient between rural poverty ratio and degraded forest land is 0.41 which is positive as expected and

statistically significant at 5 percent level. The correlation coefficients of rural poverty with other categories of waste land are either statistically insignificant or have unexpected signs. Rural poverty seems to be causing only forest degradation. Poverty does not seem to cause other types of waste land in India, however. Therefore, we partially accept the third hypothesis that poverty causes environmental degradation.

6.7. Poverty and Environmental Pollution

Air quality is deteriorating especially in metropolitan cities, mainly due to vehicular emissions. There is evidence that the health of over 900 million urban people around the world is deteriorating daily because of high levels of ambient air pollutants. The toxicology of air pollution is very complex as there are different types of pollutants. The pollutants in air, namely $-SO_2$, NO_2 and Suspended Particulate Matter (SPM) - damage the human respiratory and cardio-respiratory systems in various ways. The elderly, children, smokers and those with chronic respiratory diseases are the most vulnerable. It has been reported that high levels of pollution affect mental and emotional health too. Elevated levels of lead in children result in impaired neurological development, leading to lowered intelligence quotient, poor school performance and behavioral difficulties.

A study conducted by All India Institute of Medical Sciences and Central Pollution Control Board in Delhi showed that exposure to higher levels of particulate matter contributed to respiratory morbidity. It indicated that the most common symptoms relating to air pollution were irritation of eyes (44 per cent), cough (28.8 per cent), pharyngitis (16.8 per cent), dyspnea (16 per cent) and nausea (10 per cent) affecting the individual differently.

In Mumbai, the prevalence of both symptoms and signs of such diseases is around 22.2 per cent. Among the six major communicable diseases, maximum cases (2,58,07,722) were reported for Acute Respiratory Infection while maximum number of people (7,073) died due to Pulmonary Tuberculosis in India, during the year 2006.

Available global evidence suggests that the two most important ways in which environmental quality has a negative impact on the health of the poor is through water and indoor air pollution. Respiratory infections and diarrheal diseases are the two biggest causes of death among the poorest 20 per cent of the world's countries as ranked by national GDP per capita (Gwatkin and Guillot, 1999). Water pollution is a key source of a number of diseases such as diarrhea, malaria, and cholera. Air pollution is another major reason for concern because of its contribution to respiratory tract infections. Declines in environmental quality are likely to affect the health of the poor severely than the rich. Their low nutritional status makes the poor more vulnerable to environmentally driven illness ; and evidence suggests that water pollution and indoor air pollution affect the poor disproportionately relative to the rich (Shyamsundar, 2002). Low income is a risk factor not only for exposure to environmental hazards but also for possibilities of rapid and effective treatment due to lack of health care services (Satterthwaite, 2003).

Poverty and Indoor Air Pollution

Smoke from solid cooking fuels is a serious health hazard. Solid cooking fuels include coal/lignite, charcoal, wood, straw, shrubs, grass, agricultural crop

waste and dung cakes. To study the potential for exposure to cooking smoke from solid fuels, NFHS-3 collected information on the type of fuel used for cooking, the place that the cooking is done, and whether cooking is done under a chimney or not. Forty-nine percent of households in India cook with wood and 25 percent cook with LPG/natural gas. These percentages, however, mask the vast difference in the types of cooking fuel used in rural and urban areas. In rural areas, cooking is largely done with solid fuels. Sixty-two percent of households in rural areas use wood for cooking, 14 percent cook with dung cakes, and 13 percent use straw, shrubs, grass, and agricultural crop waste. Although the majority of urban households (59 percent) cook with LPG/natural gas, it is notable that even in urban areas, 22 percent of households use wood as their cooking fuel. Additionally, 8 percent of urban households cook with kerosene.

Overall, these data show that the vast majority of rural households (90 percent) and one third of urban households (31 percent) use solid fuels for cooking that generate smoke and unhealthy conditions when inhaled. Additionally, 74 percent of households cook their meals in the house; the remaining quarter cook outside the house or in a separate room. About one third of households (32 percent) cook inside the house, without having a separate room for cooking. In both urban and rural areas, 9 in 10 households that use solid fuels, cook on an open fire, without diverting the smoke through a chimney.

Use of solid fuel (wood, animal dung, crop residue/grasses, coal, and charcoal) exposes people to high levels of toxic air pollutants, which result in serious health consequences. National Family Health Survey-3 (NFHS) found that

71 per cent of India's urban households and 91 per cent of rural households use solid fuels for cooking purposes.

There is a great deal of variation in the prevalence of TB according to the type of cooking fuel the household uses. It ranges from a low of 217 per 100,000 residents, (among households using electricity, liquid petroleum gas, natural gas, or biogas), to a high of 924 per 100,000 (among households using straw, shrubs, or grass for cooking). Studies have found that besides TB, acute respiratory infections, chronic obstructive pulmonary disease, asthma, lung cancer, ischaemic heart disease and blindness can also be attributed to indoor air pollution.

Poor in rural areas are largely dependent on solid fuels for cooking. They log forests and trees to meet their energy needs. Burning of solid fuels leads to environmental pollution in general and indoor air pollution in particular. The victims of this indoor air pollution are poor themselves as they have no separate kitchen. The health of women and children are specially affected the most as they spend most of their time in-house.

The following correlation matrix depicts the correlation coefficients between percentage of people using solid fuel in rural areas, rural poverty ratio, percentage of acute respiratory cases and percentage of TB cases in twenty eight states of India in year 2004-05. Correlation coefficient of each pair of variables is found to be positive as expected. Correlation coefficients of rural poverty ratio with percentage of people using solid fuel in rural areas and percentage of TB cases in rural areas are respectively 0.27 and 0.28 which are positive as expected and statistically significant at 10 percent level (Table: 6.19). The results show that rural poor in

India are heavily dependent on forests and animal products for fuel needs. The burning of solid fuel by poor in rural areas are naturally principal sources for CO_2 emission at large scale in rural areas. TB cases largely prevail in rural areas among rural poor in India. However, given the insignificant correlation coefficient, there is little evidence that the use of solid fuel by rural poor for cooking purposes cause TBs to poor in rural areas. The insufficient food intake and over physical workload could be the main factors causing TBs among the rural poor in India. This leads the study to accept the hypothesis that poverty causes environmental degradation in rural areas of India.

Table: 6.19
Correlation Matrix
Poverty Ratio, Solid Fuel Use and Air Pollution Related Diseases in Rural areas of India

Variables	Percentage of people using solid fuel for cooking in rural areas	Rural poverty ratio	Under five children (%) with symptoms of acute respiratory infection	TB cases (%)
Percentage of people using solid fuel for cooking in rural areas	1	0.27*	0.11	0.12
Rural poverty ratio	0.27*	1	0.08	0.28*
Under five children (%) with symptoms of acute respiratory infection	0.11	0.08	1	0.08
TB cases (%)	0.12	0.28*	0.08	1

Source: Planning Commission & NSSO Data, 61st Round. NSS Report No. 511: Energy Sources of Indian Households for Cooking and Lighting, 2004-05. Source for data on TB cases and acute respiratory cases is NFHS-3, 2005-06.
Note: * indicates that the correlation coefficients are statistically significant at 10 percent level.

Poverty and Water Pollution

Water is an important resource for economic development of a country. The growing population directly increases pressure on demand for more safe drinking water and for other domestic uses. Hence, the costs for providing more safe drinking water also increase. It also increases the demand for water for the irrigation of more land area, industrial uses, energy production and other uses. The same activities lead to large scale pollution of ground and surface water solid waste generation which cause human diseases and loss of water bodies. Hence, the growing population eventually leads to environmental degradation which in turn affects human lives adversely.

Available global evidence suggests that the two most important ways in which environmental quality has a negative impact on the health of the poor is through water and indoor air pollution. Respiratory infections and diarrheal diseases are the two biggest causes of death among the poorest 20 per cent of the world's countries as ranked by national GDP per capita (Gwatkin and Guillot, 1999). Water pollution is a key source of a number of diseases such as diarrhea, malaria, and cholera. Air pollution is another major reason for concern because of its contribution to respiratory tract infections. Declines in environmental quality are likely to affect the health of the poor severely than the rich. Their low nutritional status makes the poor more vulnerable to environmentally driven illness ; and evidence suggests that water pollution and indoor air pollution affect the poor disproportionately relative to the rich (Shyamsundar, 2002).

The access to safe drinking water has been constantly improving both at national level and across states in India since 1981. Still a large number of people don't have access to safe drinking water in India. About 22 per cent people in India don't have access to safe drinking water as per the Census, 2001. Moreover, there is wide rural-urban disparity in the access to safe drinking water in India. While about 90 per cent people have access to safe drinking water in urban areas, only 73.2 per cent people have access to safe drinking water in rural areas. Six out of fifteen major states had percentage of population with access to safe drinking water below national percentage of 73.2 in rural areas of in 2001. The number of such states was five in urban areas in the same year (Table: 6.20).

Table: 6.20
Access to Safe Drinking Water in Households (%) in Major States of India

	1981			1991			2001		
States	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Andhra Pradesh	25.9	15.1	63.3	55.1	49.0	73.8	80.1	76.9	90.2
Assam	NA	NA	NA	45.9	43.3	64.1	58.8	56.8	70.4
Bihar	37.6	33.8	65.4	58.8	56.5	73.4	86.6	86.1	91.2
Gujrat	52.4	36.2	86.8	69.8	60.0	87.2	84.1	76.9	95.4
Haryana	55.1	42.9	90.7	74.3	67.1	93.2	86.1	81.1	97.3
Karnataka	33.9	17.6	74.4	71.7	67.3	81.4	84.6	80.5	92.1
Kerala	12.2	6.3	39.7	18.9	12.2	38.7	23.4	16.9	42.8
Madhya Pradesh	20.2	8.1	66.7	53.4	45.6	79.4	68.4	61.5	88.6
Maharashtra	42.3	18.3	85.6	68.5	54.0	90.5	79.8	68.4	95.4
Orissa	14.6	9.5	51.3	39.1	35.3	62.8	64.2	62.9	72.3
Punjab	84.6	81.8	91.1	92.7	92.1	94.2	97.6	96.9	98.9
Rajasthan	27.1	13.0	78.7	59.0	50.6	86.5	68.2	60.4	93.5
Tamil Nadu	43.1	31.0	69.4	67.4	64.3	74.2	85.6	85.3	85.9
Uttar Pradesh	33.8	25.3	73.2	62.2	56.6	85.8	87.8	85.5	97.2
West Bengal	69.7	65.8	79.8	82.0	80.3	86.2	88.5	87.0	92.3
All India	38.2	26.5	75.1	62.3	55.5	81.4	77.9	73.2	90.0

Source: Office of the Registrar General, India.
N.A.-Not available

Unsafe drinking water poses serious health problems for the poor people in rural areas. The rural poor are especially vulnerable to various types of water-borne diseases which negatively affect their earning capacity. Besides, it increases their medical expenses and hence depletes their purchasing power further. Due non

availability of water in their vicinities the rural poor have to cover a long distance for fetching water for different uses which consumes a lot of their time and energy.

Lack of availability of safe drinking water to rural poor makes them, specially children, vulnerable to various types of water borne diseases which not only increase their medical expenses but also affect their earning capacity adversely. The access to safe drinking water has been constantly improving both at national level and across states in India since 1981. Still a large number of people don't have access to safe drinking water in India. About 22 per cent people in India don't have access to safe drinking water as per the Census, 2001. There is wide varaiations in the access to safe drinking water across states in India from lowest 23.4 percent in Kerala to highest 97.6 percent in Punjab in 2001 (Table: 6.20) .

Table: 6.21
Projected Annual Requirement of Water by Different Uses

(Water Demand in Km^3 or BCM)

Sector	2010		2025		2050	
	Total	% share	Total	% share	Total	% share
Domestic	688	84.62	910	83.26	1072	74.08
Irrigation	56	6.89	73	6.68	102	7.05
Industry	12	1.48	23	2.10	63	4.35
Energy	5	0.62	15	1.37	130	8.98
Others	52	6.40	72	6.59	80	5.53
Total	813	100.00	1093	100.00	1447	100.00

Source: Central Water Commission, Working group Report on Water Resources for the XI Five Year Plan.
BCM: Billion Cubic Meters.

Table: 6.21 shows the projected annual requirement of water by different uses in the year 2010, 2025 and 2050. It can be observed from the table that the largest demand for water will come from domestic sector followed by irrigation, industry, and energy in year 2010. The demand for water for domestic requirement will rise from 688 billion cubic meters (BCM) in 2010 to 910 BCM in 2025 and further to1072 BCM in 2050. The energy requirement of water will increase by 26

times between 2010 2050. It will increase from 5 BCM in 2010 to 15 BCM in 2025 which will further rise to 130 BCM in 2050. One can imagine the scale of pressure of increasing population on water resources and resultant level of water pollution in India in the coming years.

6.8. Concluding Remarks

Population growth rate in India is still high and there is scope for considerable reduction in it particularly in poor and heavily populated states. The rural India as a whole witnessed a significant progress in poverty reduction. However, the progress made was uneven across the states. Punjab, Haryana, Uttar Pradesh, Rajasthan, Bihar, Gujarat, Himachal Pradesh, Orissa and Madhya Pradesh were the states which witnessed lowest decline in rural poverty ratio during 1977-78 to 2004-05. These include all the five BIMARU states.

The study provides some important insights into the interrelationship between population, poverty and environmental degradation and other socio-economic factors affecting them that might be useful for policy formulations for rural development and environmental planning.

Larger population leads to more poverty and worsens the environment, and creates vicious cycle. Poverty among other factors causes growth in population. Population growth has a negative impact on environment in many ways. It leads to deforestation in rural areas, and waste water, and solid waste generation in metro cities. The growing population leads to rise in demand for transportation which causes air pollution. It also increases demand for timber for fuel and housing purposes leading to deforestation. The growth in population leads to decline in

land-man ratio leading to intensive use of natural resources and hence their degradations.

Poverty does not cause all types of environmental degradation. Poverty is, however, found to cause degradation in forests which play vital role for maintaining environmental quality. Poverty leads to environmental degradation by causing population growth and density in a multiple way. The study infers in consonance with the dominant view in the literature that poverty spurs environmental (forests and rainfall) degradation.

The analysis of state and block level data on forests, rainfall and temperature show that the environment in poor and backward BIMARU states and North-eastern states of India has deteriorated. Poverty in India is largely concentrated in rural areas. Around 72 percent poor in India live in rural areas. The rural poor are mainly dependent on agriculture and allied sectors which are mainly dependent on natural resources. A vast area of agricultural land (about 40) is still dependent on rainfall. Therefore, forests and rainfall degradation adversely affect the agricultural productivity and income and employment of the poor in rural areas. Environmental pollution also increases the severity of rural poverty in that it decreases their working capacity and increases medical expenses. In fact the poor are found to be main victims of environmental degradation. Hence, environmental degradation increases rural poverty and rural poverty spurs environmental degradation. Poverty-environment vicious circle seems to be in operation in rural areas in that poverty leads to increase in solid fuel use which in turn causes diseases among the rural poor.

The study also finds that social factors also play important role in environmental change and poverty change. Education facilitates the adoptability of clean-technology and improving the quality of environment. The BIMARU states of India are characterized by high poverty ratio, poor demographic features (high population growth rate, high fertility rate, etc.), poor health indicators (high infant mortality rate, low life expectancy, lack of sanitation and access to safe drinking water) and low literacy rates. In short, these states rank very low in human development indicators. Since the combined population of the five BIMARU states is more than 40 per cent of India's total population, the poor socio-economic conditions of these states naturally pull the overall socio-economic conditions of India down a great deal. The poor in these states are largely dependent on agriculture for their livelihoods. A vast area of land is degraded due to water erosion in these states. The quality of the environment, as reflected in the forest and rainfall degradation, has deteriorated in the BIMARU states. Moreover, these states have a very low area of forests cover of their total land mass. Reforestation can play an important role in moderating the influence of floods, checking soil erosion, maintaining fertility of soil, conserving water, and regulating hydro-cycles. Concerted efforts have to be made on reducing, poverty, population growth, improving health and sanitation facilities for strengthening sustainable development in India. Since, poverty, population growth and environmental degradation are interrelated, and more often one causes the other, we should not deviate from the policy of making a joint attack on poverty, population, and environmental degradation. Since poorest of the poor eke out their precarious living from natural

resources like forests, rivers, lakes etc., environmental degradation would undoubtedly have its effects on them. Similarly increase in incidence of poverty would surely increase the desperate onslaught on Nature. This is amply borne out by the case of the N.E. Region where shifting cultivation on the hill slopes has established a vicious circle of poverty of the hill men and denudation of forests leading to environmental degradation. Hence, a harmonized development of human, social and natural capital is required for the sustainable development of the BIMARU states and India.

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CHAPTER-VII
FINDINGS, CONCLUSION AND SUGGESTIONS

Various statistical and econometric techniques were applied to find scientific results in the present study. The in-depth study was done through secondary data analysis. Relevant variables were identified, analysed and correlated to extract information implicit in the data and cause-effect relationships were established wherever possible by supplying theoretical base or reasoning. Based on the stated objectives of the study, the important findings have been enlisted, conclusion has been drawn and suggestions have been made for policy formulations as follows:-

7.1. Important Findings of the Study

1. Structural Stability Test of Net National Product (NNP) and Per Capita Net National Product using dummy variable technique showed a significant rise in both intercepts and slopes of the two functions in the post reform period.
2. The same test also showed a significant decline in the rate of population growth in the Post-reform period.
3. The Compound Annual Growth Rates of NNP and Per Capita Net National Product have significantly risen in post-reform period from 1993 to 2005 as compared to pre-reform period from 1983 to 1991.
4. The rise in growth rate of per capita income has not only been contributed by higher growth rate in NNP but also partially by lower growth rate in population in the post reform period.

5. Both σ and β-convergence test show that Indian states in terms of Per Capita Net State Domestic Product (PCNSDP) have not converged (diverged) in the post-reform period.
6. However, the rapidity of divergence seems to have slightly subsided in the post-reform period.
7. The rate of decline in poverty ratio has been significantly higher in rural areas than in urban areas in the post-reform period. However, the large and poor states (Bihar, Madhya Pradesh, Rajasthan and Orissa) experienced deterioration in poverty-elasticities of per capita net state domestic product and net state domestic product in the post-reform period. This could have been possible due to the introduction of a number of direct poverty alleviation programmes in rural areas facilitated by surplus resources due to impressive economic growth in the post reform period.
8. Population growth rate was found to be significantly higher in BIMARU states as well as North-eastern states in comparison to rest of India.
9. Literacy rate has a positive impact on population growth rate in India.
10. Male child preference in Indian society for which sex ratio was used as a proxy was found to be the most important factor contributing to population growth in India.
11. Increase in urbanization has no impact on population growth.
12. High infant mortality rate leads to high population growth rate.
13. Poverty also causes population growth in India.
14. Population growth has a negative impact on environment in multiple ways.

15. The analysis of state level secondary data to explore poverty-environment nexus in rural India by constructing poverty and environmental degradation and composite index did not show any definite poverty-environment nexus pattern.

16. However, the analysis of block level data on rainfall and dispersion in temperature shows that environment has deteriorated in both the BIMARU states and North-eastern states of India between 1991 and 2001.

17. There is a two-way causal relationships between poverty and environmental degradation, i.e. poverty causes environmental degradation and vice verse. But these relationships are found to be indirect. Moreover, it does not imply that the rich do not cause the environment to degrade. In fact, whether the environmental degradation is caused by the rich and powerful or by the poor depends on the type of environmental degradation. While the rich as well as the poor could be the agent for environmental pollution, the adverse impact of it is disproportionately on the poor due to their direct dependency on natural resources for income, employment and livelihoods. The poor are also more vulnerable and exposed to environmental pollution due to their poor nutritious and living conditions.

18. Poverty causes population growth which leads to environmental degradation in more than one ways. Hence, we infer from this that poverty leads to environmental degradation by causing population growth in the long run.

7.2. Concluding Remarks

Our in-depth study using analytical tools of statistics and econometrics offers certain evidences on growth, inequality and poverty in India. There have been significant upward shifts in the growth rates of net national product and per capita net national product in India as a consequence of major economic policy shift in 1991 popularly known as the economic reform. Although net national product and per capita net state domestic product both experienced spectacular rise in real terms in the post-reform period, the impressive growth in per capita income cannot be solely attributed to the economic reform of 1991. The improvements in standard of living of people in India as reflected in real per capita income in the post-reform period was also due to slow down in the population growth rate besides the higher economic growth in the post-reform period.

It is quite worrying that while there has been overall impressive achievement on growth fronts in India, the growth disparity between the agriculture and non-agriculture sectors has widened in the post-reform period. The poor in India is still mostly concentrated in rural areas and they are mainly dependent on agriculture and allied sectors. Each of agriculture & allied and agriculture sector witnessed a significant fall and the industrial sector a slight rise in growth rate in the post-reform period. Only service sector registered a marked rise in its growth rate in the post-reform period. Service sector was the only sector which witnessed positive structural change in its growth rate in the post-reform period.

The change in the sectoral pattern of growth in the post-reform period has been neither in favour of the poor states nor in favour of the poor people in India.

The impressive increase in growth rate in non-agriculture sectors particularly in service sector and considerable slow down in the agricultural sector growth rate in the post-reform period resulted in economic disparities between the rich and the poor states of India in the post-reform period. This could be due to the fact that most of the states which are heavily populated also house most of the poor people who are mainly dependent on agriculture for their income and employment. The increasing economic disparity itself partly explains that the benefits of higher economic growth were largely appropriated by the rich states and the rich people.

The poverty elasticity in India is estimated to be 2.093 in the pre-reform period which declined to 1.826 in the post-reform period. Out of the major eight states of India which witnessed deterioration in their poverty elasticities (arc elasticity of poverty), four were the so called BIMARU states. Uttar Pradesh was the only BIMARU state which registered an improvement in its poverty elasticity in the post-reform period.

Thus, India has partially failed in translating the higher growth achieved in the post-reform period into poverty reduction effectively. Hence, in spite of impressive economic growth the achievement on poverty front has not been so impressive during the post-reform period.

India has achieved some success on population front but there is still a lot of scope for the reduction of population growth rate in many Indian states. There are particularly high rates of population growth in most of the North-eastern and BIMARU states of India. The population in large and poor Indian states namely

Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh and Orissa continues to grow at a very high rate. The preference for male child, poverty and illiteracy are the major factors contributing to higher population growth in India. The prevalence of high infant and child mortality rates in relatively poor states are also contributing to the high growth rate of population. The low chance of the survival of a child leads people to have more children to avoid the risk of being child-less.

The high population growth rate and the stagnant low growth of Indian agriculture in the post reform period have exacerbated the income and employment situation for the poor people dependent on agriculture in rural areas. The service sector has consistently experienced higher growth rate in the post-reform period. This growth of service sector is more conducive to sustainable development as employment elasticity of growth in this sector is relatively high in comparison to other sectors. The service sector is least dependent on natural resources. Hence, natural resources are not subjected to intensive use when its growth picks up. It is human capital-intensive. Therefore, ensuring the supply of efficient human-capital on a continuous basis is the key to consistent higher growth of service sector in India. Promotion of education will serve the dual purpose- on one hand it will accelerate the growth of service sector and on the other it will help stabilize the population growth via reducing the fertility rate of women directly. Education, particularly girls' education, has a significant positive impact on fertility rate among women in the age group 15-49, 19-24 and 20-29. It is here remarkable that fertility rate in India is highest in the age groups 19-24 and 20-29 years. The years of higher education of girls in India coincides with these two age groups. Thus, the

romotion of higher education in general and girls' education in particular is key to educing the population growth and smooth and continuous high rate of growth of he service sector and , hence, for sustainable economic development in India.

Population growth rate in India is still high and there is scope for onsiderable reduction in it particularly in poor and heavily populated states. The ural India as a whole witnessed a significant progress in poverty reduction. Iowever, the progress made was uneven across the states. Punjab, Haryana, Uttar radesh, Rajasthan, Bihar, Gujarat, Himachal Pradesh, Orissa and Madhya Pradesh vere the states which witnessed lowest decline in rural poverty ratio during 1977-'8 to 2004-05. These include all the five BIMARU states.

The study provides some important insights into the interrelationship etween population, poverty and environmental degradation and other socio-conomic factors affecting them that might be useful for policy formulations for ural development and environmental planning.

Larger population leads to more poverty and worsens the environment, and reates vicious cycle. Poverty among other factors causes growth in population. opulation growth has a negative impact on environment in many ways. It leads to leforestation in rural areas, and waste water, and solid waste generation in metro ities. The growing population leads to rise in demand for transportation which auses air pollution. It also increases demand for timber for fuel and housing urposes leading to deforestation. The growth in population leads to decline in

land-man ratio leading to intensive use of natural resources and hence their degradations.

Poverty does not cause all types of environmental degradation. Poverty is, however, found to cause degradation in forests which play vital role for maintaining environmental quality. Poverty leads to environmental degradation by causing population growth and density in a multiple way. The study infers in consonance with the dominant view in the literature that poverty spurs environmental (forests and rainfall) degradation.

The analysis of state and block level data on forests, rainfall and temperature show that the environment in poor and backward BIMARU states and North-eastern states of India has deteriorated. Poverty in India is largely concentrated in rural areas. Around 72 percent poor in India live in rural areas. The rural poor are mainly dependent on agriculture and allied sectors which are mainly dependent on natural resources. A vast area of agricultural land (about 40) is still dependent on rainfall. Therefore, forests and rainfall degradation adversely affect the agricultural productivity and income and employment of the poor in rural areas. Environmental pollution also increases the severity of rural poverty in that it decreases their working capacity and increases medical expenses. In fact the poor are found to be main victims of environmental degradation. Hence, environmental degradation increases rural poverty and rural poverty spurs environmental degradation. Poverty-environment vicious circle seems to be in operation in rural areas in that poverty

leads to increase in solid fuel use which in turn causes diseases among the rural poor.

The study also finds that social factors also play important role in environmental change and poverty change. Education facilitates the adoptability of clean-technology and improving the quality of environment. The BIMARU states of India are characterized by high poverty ratio, poor demographic features (high population growth rate, high fertility rate, etc.), poor health indicators (high infant mortality rate, low life expectancy, lack of sanitation and access to safe drinking water) and low literacy rates. In short, these states rank very low in human development indicators. Since the combined population of the five BIMARU states is more than 40 per cent of India's total population, the poor socio-economic conditions of these states naturally pull the overall socio-economic conditions of India down a great deal. The poor in these states are largely dependent on agriculture for their livelihoods. A vast area of land is degraded due to water erosion in these states. The quality of the environment, as reflected in the forest and rainfall degradation, has deteriorated in the BIMARU states. Moreover, these states have a very low area of forests cover of their total land mass. Reforestation can play an important role in moderating the influence of floods, checking soil erosion, maintaining fertility of soil, conserving water, and regulating hydro-cycles. Concerted efforts have to be made on reducing, poverty, population growth, improving health and sanitation facilities for strengthening sustainable development in India. Since, poverty, population growth and environmental degradation are interrelated, and more often one causes the other, we should not deviate from the

policy of making a joint attack on poverty, population, and environmental degradation. Since poorest of the poor eke out their precarious living from natural resources like forests, rivers, lakes etc., environmental degradation would undoubtedly have its effects on them. Similarly increase in incidence of poverty would surely increase the desperate onslaught on Nature. This is amply borne out by the case of the N.E. Region where shifting cultivation on the hill slopes has established a vicious circle of poverty of the hill men and denudation of forests leading to environmental degradation. Hence, a harmonized development of human, social and natural capital is required for the sustainable development of the BIMARU states and India.

7.3. Suggestions

The following suggestions are offered in the light of the problems currently being faced by India which can prove to be very effective for its environmentally sustainable development.

Tax based on Households Size

Since solid waste and waste water generation are highly correlated with size of population, the pollution tax should be levied in proportion to the size of households. In order to check air pollution from vehicles licence fee on them should be raised on old vehicles after the expiry of a fixed period as pollution from vehicles increases as they get older.

Tax based on pollution load

Presently, effluent standards are based on best available technology for specific industries. Industries have no incentive to improve standards in such a

system. Instead, a pollution tax should be levied so that industries pay taxes in proportion to the pollution they generate. Such a policy will reduce pollution at source and can only work if there is effective monitoring and punishment.

Appropriate pricing

Natural resources are often sold at a very low price, leading to their exploitation. For example, the subsidies on irrigation water have led to planting of highly water intensive crops in regions inappropriate for this kind of agriculture. Excessive use of water has also resulted in water logging as well as depletion of ground water table making the soil saline. Removing inappropriate subsidies is essential to maintaining natural resources and would encourage development of more environmentally friendly alternatives. Since liberalization this has changed in India. People have also begun to accept appropriate prices for natural resources. Pricing water to reflect its scarcity will encourage users to use it more sparingly.

Reduce subsidies on fertilizers and pesticides

The current subsidies on fertilizers and pesticides do not ensure that they are used sparingly. Reducing fertilizer subsidies will encourage more controlled use.

Technological interventions

Technological intervention for environmental management does not necessarily imply new inventions. Many environmentally friendly interventions are traditional methods or simple techniques, which have been known but not used.

A great example of how a cleaner technology is a mere modification of an existing one is toilets. Mexico City replaced 350,000 toilets with smaller six-litre flushes and saved enough water to meet the needs of 250,000 more homes (Mexico

City's Water Supply: Improving the Outlook for Sustainability (1995). In many cases however, active research needs to be conducted in producing cleaner technologies – such as cleaner fuel, more efficient cars etc.

Efficient irrigation

Since 84% of all water in India is used for agriculture, efficient irrigation is the best method to deal with water wastage. For example, applying water to the roots of crops through drip irrigation saves a considerable amount of water, fretless, pesticides, and electricity for irrigation. It also prevents soil erosion or water logging.

Vermiculture and organic manures

Vermiculture has been shown to be an effective method to deal with organic solid waste, which is becoming a major problem in urban areas. If the community can be made to sort their garbage (citizen sorting has been effective in many industrialized cities) this can also provide organic manure.

People's Participation

It is not possible for the government to monitor pollution and the corresponding acts of all industries and individuals. People must be made stakeholders in the environment through awareness campaigns. Industries are sensitive to public pressure. Experience in the west suggests that firms wish to maintain a green profile when citizens are aware of environmental issues. Through generating awareness, the public could directly affect the environmental practices of industries. As already pointed out right to information and liability laws help a lot in this.

Environmental problems arise because property rights are not well defined. Common property resource management is needed. Often cooperative management with people participation is advocated. However, people's participation is not the magic bullet by itself. When the common property resource is such that user group management can lead to positive sum outcome, then cooperation becomes sustainable. In a zero sum situation the cooperatives often disintegrate once the change agents leave. The problem of free-riding can be dealt through people's participation (when CPR is definable) with an appropriate management structure. For example, the national tree grower's cooperative federation has evolved a framework which has been successfully tried in hundreds of cases. The CPR is managed through a collective after defining a community, making members pay a fair price for whatever they take from the CPR and sharing profits equally among all members.

Moving forward technologically

In addition to environment–specific technologies, mentioned above, India has to move forward technologically in an overall context to avoid pollution at source. Modern technologies already developed in the developed countries such as better power plants and cleaner vehicles should be considered through technology transfer for pollution measurements.

Provide effective right to information

If people have the information about what their neighbouring industry pollutes, they would generate pressures for abatement and treatment. Full liability laws need to be complemented with right to information.

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